Research Paper on IoT Based Solar Tree Project with Integrated Inverter System

Shubham Gedam[1], Mohasin Sheikh[2], Aditya Gurnule[3], Avinash Haldar[4], Tina Rahate[5], Durga Kokude[6], Kiran Kimmatakr[7]

[1,2, 3,4,5,6]*Students of Electrical Engineering Department in Vidarbha Institute of Technology, Nagpur*

[7]*Professor of Electrical Engineering Department in Vidarbha Institute of Technology, Nagpur*

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ABSTRACT – The growing demand for renewable energy sources has led to increased interest in solar power generation. Solar trees, a novel concept in the field of renewable energy, have gained significant attention due to their efficient use of space and unique design. This research paper presents an IoT-based solar tree project with an integrated inverter system, aimed at optimizing solar power generation and enhancing energy management capabilities. The proposed solar tree system incorporates multiple solar panels arranged in the form of branches, mimicking the structure of a tree. This arrangement allows for maximum exposure to sunlight, thereby improving the overall energy harvesting efficiency[1].

To enhance the system's efficiency and monitoring capabilities, an IoT (Internet of Things) framework is integrated into the solar tree project. IoT-enabled sensors are deployed to collect real-time data on various parameters such as Battery Voltage, temperature &Humidity , and Light Intensity. This data is transmitted wirelessly to a centralized monitoring system, enabling remote monitoring and control of the solar tree system. The integrated inverter system plays a crucial role in the solar tree project by efficiently converting DC power into AC power suitable for consumption using Inverter. [3].

Keywords: Solar tree, Battery Voltage, renewable energy, solar power, IoT.

1. INTRODUCTION

The Internet of Things (IoT) technology has revolutionized various industries by enabling seamless connectivity and efficient data exchange between physical devices. In recent years, the application of IoT in the field of renewable energy, specifically solar power generation, has gained significant attention. This research paper presents an introduction to an innovative project called "IoT-Based Solar Tree" that incorporates an integrated inverter system[2]. The Solar Tree project aims to enhance the efficiency and monitoring capabilities of solar power generation while promoting sustainable energy practices. Solar power systems are becoming more and more popular all over the world as a result of the growing demand for sustainable and clean energy sources. Traditional solar installations, however, have some drawbacks, including a lack of real-time monitoring, a space crunch, and subpar energy output. The idea for the IoT-Based Solar Tree project has arisen as a solution to these problems. Through the incorporation of IoT technology, this project seeks to maximize energy production while assuring effective administration and monitoring[6].

A fresh method of harnessing solar energy is the Solar Tree concept. The proposal comprises a vertical array of solar panels installed on a central pillar that is modelled like the structure of a tree. By utilizing the vertical axis, this creative design maximizes the use of available space and allows for higher power output with a lesser environmental impact. Smart sensors and communication modules are installed in the solar panels to facilitate easy data transfer and management.

2. RELATED WORK

Solar energy is one of the reliable forms of renewable energy, many works have been done for its improvement, monitoring and control. Many solar and monitoring systems have been developed using different technologies. A typical example is the remote monitoring system based on wireless technology; this technology uses sensors that send and transmit data wirelessly. Major issue with this latter technology is the delay in transmission, which makes it vulnerable to failures. Even data transmission via wireless sensors is not highly reliable; data can be lost and this system also requires a lot of power to operate. Wi-Fi technology can be used for sending data from one end to the other end. Data transmission rate for Wi-Fi is not very high and also the system is not very complex. The only limitation involved in this method is its range and this system can be applied at micro level. Our choice of IoT rests on the availability of internet technology at different places and its easy accessibility from mobile devices. Additionally, the web monitoring platform, IoT, is a cheap platform for hosting the devices to be monitored and controlled in real time. It has an advantage of no-payment for a particular range of data upload. Prevailing knowledge on inverters deployment has shown that different inverters are rated for different maximum voltage and have higher efficiencies between different voltage ranges[4].

Thus, Engineers must carefully size the PV system in different temperature environments to ensure that the output voltage is not too high to prevent equipment damage. For example, a PV system in Arizona can have a maximum system voltage that is lower than the same system because of the higher temperatures in Arizona. Because PV panels are more efficient at lower temperatures, engineers should design systems with active and passive cooling. Cooling the PV panels allows them to function at a higher efficiency and produce more power[5].

2. PROPOSED METHODOLOGY

In solar tree system, several solar panels are organized in the shape of branches to resemble the structure of a tree. With this setup, the amount of sunlight that may be absorbed is maximized, increasing the effectiveness of the energy harvesting process. The solar tree project incorporates an IoT (Internet of Things) architecture to improve the system's efficiency and monitoring capabilities[7].
The core component of the Solar Tree project is the integration of IoT technologies. Each solar panel is equipped with sensors to measure parameters such as Battery Voltage, temperature & Humidity, and Light Intensity. These sensors continuously collect data and transmit it to a central IoT gateway. The IoT gateway acts as a bridge between the solar panels and the cloud-based monitoring system. It enables real-time monitoring, data analysis, and control of the solar tree system.

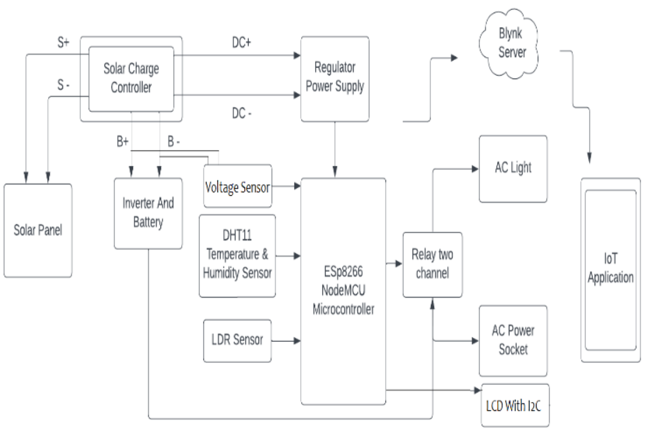

Fig -1: Block Diagram

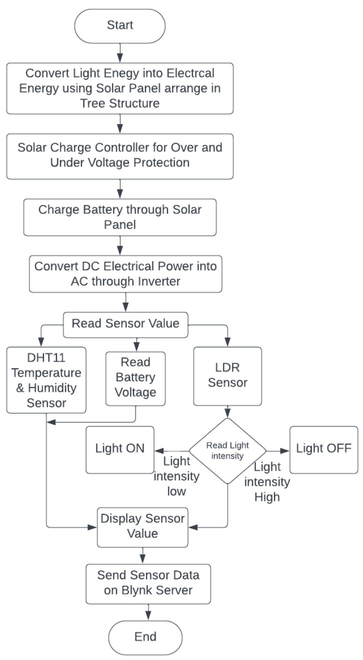

Fig -2: Flow Chart

4. COMPONENT DETAILS

ESP8266 NodeMCU Controller

The NodeMCU (Node Microcontroller Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.
Also challenging to utilize and access is ESP8266. For the simplest operations, like turning it on or sending a keystroke to the "computer" on the chip, you must solder wires with the necessary analogue voltage to its pins. Additionally, you need to programmer it in low-level machine instructions that the chip hardware can understand. Using the ESP8266 as an embedded controller chip in mass-produced devices is not problematic at this degree of integration. For amateurs, hackers, or students who want to test it out in their own IoT projects, it is a significant burden.

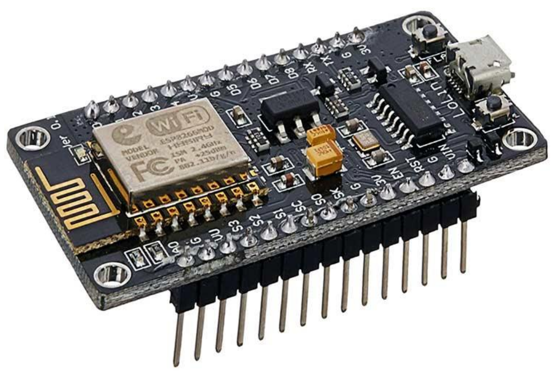

Fig -3: ESP8266 NodeMCU Controller

Solar Panel

Fig - 4: Solar Panel

A solar panel is a device that converts sunlight into electricity by using photovoltaic (PV) cells. PV cells are made of materials that generate electrons when exposed to light. The electrons flow through a circuit and produce direct current (DC) electricity, which can be used to power various devices or be stored in batteries. Solar panels are also known as solar cell panels, solar electric panels, or PV modules.

LDR Sensor

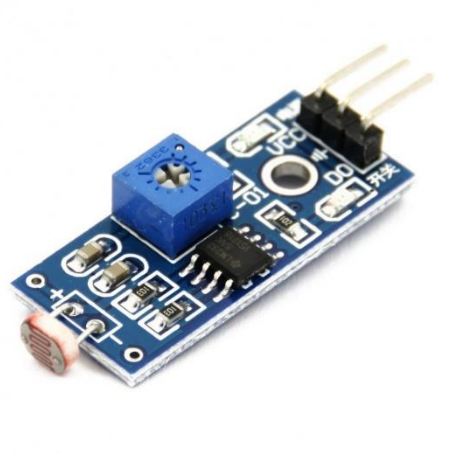

Fig -5: Soil Moisture Sensor

An LDR or light dependent resistor is also known as photo resistor, photocell, photoconductor. It is a one type of resistor whose resistance varies depending on the amount of light falling on its surface. When the light falls on the resistor, then the resistance changes. These resistors are often used in many circuits where it is required to sense the presence of light. These resistors have a variety of functions and resistance. For instance, when the LDR is in darkness, then it can be used to turn ON a light or to turn OFF a light when it is in the light.
An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits.

Voltage Sensor

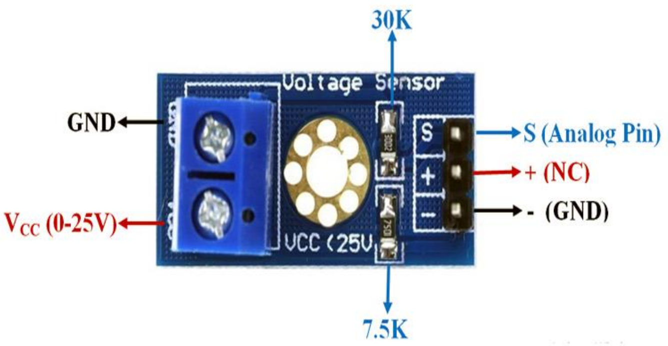

Fig -6: Voltage Sensor

A voltage sensor is a device that measures voltage. Voltage sensors can measure the voltage in various ways, from measuring high voltages to detecting low current levels. These devices are essential for many applications, including industrial controls and power systems. A voltage sensor is a device that measures the voltage of an electrical circuit. Voltage sensors are used in many applications, including monitoring and controlling equipment and machinery.

DHT11 Temperature & Humidity Sensor

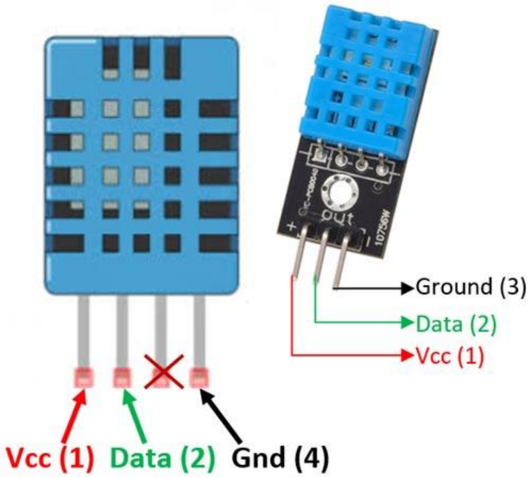

Fig -7: DHT11 Temperature & Humidity Sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

Battery

Fig - 8: Battery

A battery can be defined as an electrochemical device (consisting of one or more electrochemical cells) which can be charged with an electric current and discharged whenever required. Batteries are usually devices that are made up of multiple electrochemical cells that are connected to external inputs and outputs. Batteries are widely employed in order to power small electric devices such as mobile phones, remotes, and flashlights. Historically, the 'term' battery has always been used in order to refer to the combination of two or more electrochemical cells. However, the modern definition of the term 'battery' is believed to accommodate devices that only feature a single cell.

Inverter

Fig - 9: Inverter

A UPS Inverter is composed of sophisticated circuitry. It includes an inverter and a charge controller (usually referred to as the rectifier). The inverter switches the DC power from the battery into AC. The rectifier converts the AC utility into DC and also controls the charging parameters.

5. RESULT

An IoT-based solar tree is combines solar energy generation with the Internet of Things (IoT) technology. It involves the installation of solar panels in the shape of a tree, where the branches or leaves are equipped with solar panels to capture sunlight and convert it into electrical energy. The integrated inverter system is responsible for converting the direct current (DC) generated by the solar panels into alternating current (AC) that can be used to power electrical devices.
Also equipped with sensors to measure parameters such as Battery Voltage, temperature & Humidity, and Light Intensity. These sensors continuously collect data and transmit it to a central IoT gateway. The IoT gateway acts as a bridge between the solar panels and the cloud-based monitoring system. It enables real-time monitoring, data analysis, and control of the solar tree system. In this Project we are using Blynk Server for data Monitoring and for Controlling appliance.

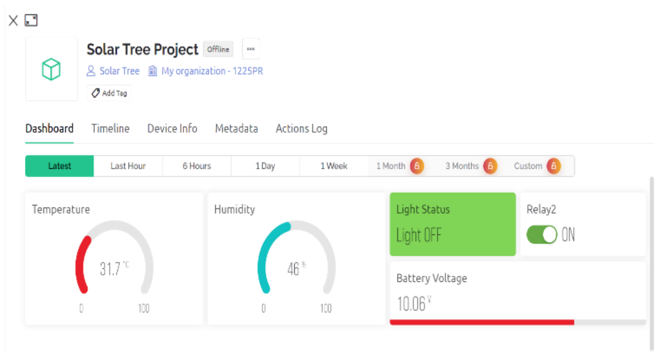

Fig - 10: IoT Application Web Dashboard Result

Fig - 9: IoT Application Mobile Dashboard Result

6. CONCLUSION

The IoT-based Solar Tree project with an integrated inverter system has proven to be a highly efficient and effective solution for harnessing solar energy and promoting sustainability. Throughout this research paper, we have explored the various aspects of this innovative project and discussed its benefits, challenges, and potential applications. IoT-based Solar Tree serves as an intelligent and aesthetically pleasing structure that maximizes solar energy generation.
By incorporating multiple solar panels arranged in the form of tree branches, it ensures optimal sunlight exposure throughout the day. The integration of IoT technology enables real-time monitoring and control of the system, allowing for efficient power management and improved performance. The integrated inverter system plays a crucial role in the Solar Tree project by converting the DC power generated by the solar panels into AC power suitable for various applications. This eliminates the need for external inverters and simplifies the overall system design.

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