A Phase-I Project Report on

"UTILIZING IOT FOR SOLAR PANEL MONITORING"

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In

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Submitted by

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CERTIFICATE

This is to certify that the project work entitled **"UTILIZING IOT FOR SOLAR PANEL MONITORING"** is a bonafied work carried out by students **JAZIB HASSAN (1GC20CS018), MOHAMMAD FARMAN (1GC20CS031), SAMEER (1GC20CS049), SYED NABIL UR RAHMAN (1GC20CS056)** of Ghousia College of Engineering in partial fulfilment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvervaraya Technological University, Belagavi during the year 2023-2024. It is certified that all the corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The Phase-I project report has been approved as it satisfies the academic requirements in respect to the technical part prescribed for the above said degree.

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ABSTRACT

The rapid integration of renewable energy sources, such as solar panels, into our power generation system has led to an increased need for efficiently monitoring and maintenance strategies. This work presents an innovative approach to monitoring and fault detection of solar panels using Internet of Things [IoT] technology. By deploying a network of sensors and communication devices, real-time data on various parameters, including temperature, voltage, current, light intensity, and panel orientation, can be collected, and transmitted to a centralized data repository. The proposed IoT-based system offers several advantages over traditional monitoring methods. It enables remote and continuous monitoring of solar panel performance, eliminating the need for manual inspections and reducing maintenance costs. The data collected from the sensors can be processed and analysed using advanced algorithms to detect anomalies, faults, and suboptimal conditions. Such timely detection allows for swift corrective actions, thereby optimizing energy generation and increasing the overall lifespan of the solar panel system.

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Chapter 1

EMBARKING ON SMART ENERGY

1.1 INTRODUCTION

Solar energy is gaining prominence as an increasingly advantageous alternative, propelled by the escalating costs of fossil fuels, their diminishing supply, and the growing imperative for sustainable energy sources like wind, solar, and geothermal options. At the heart of this transition is solar power, derived from the sun, which stands out as a reliable and environmentally friendly solution to our energy needs. The pivotal role of solar technology is exemplified by the Internet of Things (IoT)-based solar monitoring systems. These systems not only enhance the efficiency of solar panels but also offer the convenience of real-time monitoring through the internet from any location. This technological marvel enables solar panels to dynamically rotate from East to West, optimizing their exposure to sunlight throughout the day. The integration of IoT in solar energy infrastructure underscores the adaptability and sophistication of renewable energy systems, marking a significant step towards a sustainable future. The shift towards solar energy is not merely a technological trend but a necessity driven by multiple factors. The burgeoning demand for energy, coupled with the finite nature of fossil fuel resources and their escalating costs, underscores the urgency of transitioning to more sustainable alternatives. Solar power emerges as a front-runner in this pursuit, offering a virtually limitless and clean source of energy. As we witness the adverse impacts of climate change and the perils associated with greenhouse gas emissions, the adoption of solar technology becomes not only feasible but imperative for mitigating environmental risks. In this context, the harnessing of solar energy becomes a moral and practical imperative. The potential of solar power to meet our energy needs in an eco-friendly manner positions it as a cornerstone of a responsible energy strategy. Embracing solar technology allows us to significantly reduce our reliance on fossil fuels, mitigating the adverse environmental effects associated with their extraction, production, and consumption. The call to harness as much solar energy as possible is a rallying cry for a sustainable future. Governments, businesses, and individuals alike must actively contribute to the widespread adoption of solar technology. This involves not only investing in solar infrastructure but also fostering research and development to further enhance the efficiency and affordability of solar solutions. Through concerted efforts, we can usher in an era where solar energy plays a pivotal role in powering our world, offering a cleaner, greener, and more sustainable alternative to conventional energy sources.

1.2 Objectives of the project

- A solar monitoring system utilizing IoT collects real-time data on solar production, enabling remote monitoring from any location through the internet.
- Examine data for power generation, evaluating its efficiency, output, and trends to optimize and enhance overall energy production processes.
- Display data both offline and online by utilizing a cloud server, ensuring accessibility and synchronization for efficient information management.
- Aiding in pinpointing faults, it facilitates the identification of issues within solar panels, contributing to efficient troubleshooting and maintenance.
- It offers a user-friendly interface, ensuring ease of interaction for users to navigate and engage with the system seamlessly.

1.3 Existing System

While conventional non-renewable energy sources are diminishing, the utilization of renewable resources for energy generation is on the rise. Solar energy technology stands out as an excellent choice for harnessing natural assets. It involves the collection of solar energy through solar panels, its conversion into electrical power, and subsequent storage in batteries for on-demand usage. This monitoring system furnishes straightforward information regarding diverse solar parameters, facilitates fault detection, and addresses associated energy losses. Enhancing the efficiency of this work can be achieved through the incorporation of solar trackers which utilize maximum power point tracking mechanisms (MPPT). This system evaluates the sun's position and directs the movement of solar panels to optimize sun exposure on their surface. MPPT solar charge controllers, equipped with algorithms for maximum power point tracking, have been devised to substantially amplify the current supplied to batteries from photovoltaic modules. This work presents an innovative IoT-based solution designed for the detection and diagnosis of issues in solar PV panels. The primary objective of this approach is to enhance the performance and dependability of solar PV panels, which are susceptible to a range of problems like shading, soiling, degradation, and electrical malfunctions. The system incorporates wireless sensor nodes strategically placed on the panels to gather data concerning their electrical characteristics and environmental factors, including temperature, irradiance, and humidity.

1.4 Proposed System

The cutting-edge Solar Panel Monitoring System, employing Internet of Things (IoT) technology, is designed to optimize the efficiency, reliability, and sustainability of solar energy generation. This innovative system utilizes IoT to collect and analyse data from solar panels in real-time, offering remote-control capabilities and providing valuable insights. The system facilitates the continuous monitoring and collection of energy generation data, which is then transmitted to a cloud server, enabling monitoring from anywhere in the world.

Key Features:

1. **Real-time Data Collection:** The system employs IoT sensors and devices installed on each solar panel to collect real-time data on various parameters, including energy production, temperature, humidity, and voltage.
2. **Data Transmission:** Data collected from the solar panels is transmitted securely to a centralized cloud-based platform. This ensures that the information is accessible from anywhere and can be monitored by relevant stakeholders.
3. **Analytics and Monitoring:** Advanced analytics and machine learning algorithms are used to process the data, enabling the system to detect issues such as panel malfunctions, shading, or dirt build-up. System operators can monitor the performance of individual panels and the entire array in real-time.
4. **Energy Efficiency:** By continuously monitoring panel performance and making real-time adjustments, the system maximizes energy output, contributing to increased efficiency and return on investment for solar installations.
5. **User-Friendly Interface:** The user interface is designed to be intuitive, allowing users to access comprehensive data and control functionalities easily. It can be accessed via web or mobile applications.

1.5 What extra features do we add in this project?

- Cloud-based monitoring is essential for managing and optimizing resources and workloads in cloud environments.
- Implemented through automated software tools, providing comprehensive insights for cloud administrators.

- Offers a centralized platform for real-time tracking, enabling proactive issue identification and timely response.
- Primary goal is to measure workloads against specific metrics, ensuring optimal cloud tenancy operations.

Chapter 2

LITERATURE SURVEY

Vishal Singh et.al., "IoT based solar power monitoring system"

This work presents a solution and methodology for effectively monitoring dust accumulation on solar panels, aimed at optimizing power output for practical utilization. The performance of solar panel is inherently tied to the energy received by its solar cells. The anticipated system not only ensures the display of malfunctioning solar panels but also indicate s whether electrical appliances are being directly powered by the solar panel or if the load is being supplied by the battery. This work involves the creation of IoT-based systems aimed at achieving optimal power output from the solar panels even in presence of dust accumulation. Additionally, a monitoring system has been developed to promptly identify any malfunctions in the solar panels. This system also provides information about whether the loads are being powered by solar panels.

Balakrishnan D et.al., "IoT-based system for fault detection and diagnosis in solar pv panels"

This work presents an innovative IoT-based solution designed for the detection and diagnosis of issues in solar PV panels. The primary objective of this approach is to enhance the performance and dependability of solar PV panels, which are susceptible to a range of problems like shading, soiling, degradation, and electrical malfunctions. The system incorporates wireless sensor nodes strategically placed on the panels to gather data concerning their electrical characteristics and environmental factors, including temperature, irradiance, and humidity. This data is subsequently transmitted to a central server for in-depth analysis and processing using machine learning algorithms. Importantly, this system has the ability to swiftly identify and diagnose faults in real-time, issuing alerts and offering recommendations to maintenance personnel for timely interventions to avert further damage or downtime. Compared to traditional manual inspection and maintenance practices, this system offers multiple advantages, such as reduced downtime, lower maintenance expenditures, and enhanced energy efficiency. The viability of this system has been substantiated through rigorous experimental tests, conclusively demonstrating its remarkable accuracy and efficiency in fault detection and diagnosis for solar PV panels.

T. Asha Rakshana et.al., “IoT based solar panel fault monitoring and control by using wi-fi modem”

To ensure optimal power generation from solar the power plants, a comprehensive monitoring strategy is imperative. This work facilitates the attainment of efficient power production by identifying and rectifying issues such as faulty solar panels, connectivity problems, dust accumulation on panels, and other factor that can undermine solar performance. This work introduces a hardware design for an intelligent grid home gateway, seamlessly integrating a smart home network with photovoltaic (PV) integration within the solar system. Detection of faults occurs through the comparison of the Light Dependent Resistor (LDR) sensor intensity with the voltage measured from the panel. Our system maintains a continuous monitoring process of solar panel and subsequently transmits the power output data to IoT system via internet connectivity.

Preethi Sekar et.al., “IoT-based Solar Energy Monitoring”

While conventional non-renewable energy sources are diminishing, the utilization of renewable resources for energy generation is on the rise. Solar energy technology stands out as an excellent choice for harnessing natural assets. It involves the collection of solar energy through solar panels, its conversion into electrical power, and subsequent storage in batteries for on-demand usage. This monitoring system furnishes straightforward information regarding diverse solar parameters, facilitates fault detection, and addresses associated energy losses. Enhancing the efficiency of this work can be achieved through the incorporation of solar trackers which utilize maximum power point tracking mechanisms (MPPT). This system evaluates the sun's position and directs the movement of solar panels to optimize sun exposure on their surface. MPPT solar charge controllers, equipped with algorithms for maximum power point tracking, have been devised to substantially amplify the current supplied to batteries from photovoltaic modules.

P. Sampurna Lakshmi et.al., “Solar Panel Fault Detection System using IoT”

Solar parks are rapidly emerging as a pivotal form of renewable energy systems, underscoring the urgency for optimized utilization of their resources while tackling errors and performance challenges. To address these concerns, the Internet of Things (IoT) technology presents an accessible, cost-effective, and sustainable solution for enhancing solar park efficiency. In this work, we outline a monitoring and alert system designed to proactively detect Potential Induced Degradation (PID) and Hotspot failures issues that can significantly impair solar panel performance. This entails continuous monitoring of essential metrics such as temperature, voltage, and humidity at the panel level. Thorough functional testing of the complete circuit has been conducted, confirming its seamless compatibility with the application software. The design implemented in this study offers a combination of portability and adaptability, facilitating efficient data transfer with minimal power consumption.

Darshan Nandurkar et.al., "Solar Energy Monitoring System Using IoT"

Renewable energy is a type of energy, that is derived from ongoing natural processes and energy of natural processes converted into available forms. Solar energy is any type of energy that is generated by the sun. To make use of this energy and convert it into electricity we use solar panels. The IoT allows objects to be sensed or controlled remotely over existing network infrastructure, creating opportunities for pure integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. This technology has many applications like Solar cities, Smart villages, Micro grids, and Solar Street lights and so on. As Renewable energy grew at a rate faster than any other time in history during this period. The proposed system refers to the online display of the power usage of solar energy as a renewable energy. This monitoring is done through atmega328p using ATMEGA328P IDE. Smart Monitoring displays voltages of renewable energy. This helps the user to analysis of energy generation. Analysis impacts on the renewable energy usage and electricity issues.

Mirsad Hyder Shah et.al., "IoT based efficient solar panel monitoring"

The invention of smart grid has already outdated the conventional method of one-way power production supply concept. While developed countries have already started to adopt smart meters, appliances, and renewable energy sources: underdeveloped and developing countries are still facing power shortages every day. In the second Industrial Revolution, electricity was the main advancement, and the recent Industrial Revolution 4.0 has pushed giant Production companies into the adoption and promotion of Renewable Energy sources. The integration of IoT and power systems has revolutionized the world in terms of power efficiency and real time monitoring. This paper discusses an experimental work done on how IoT can monitor the power/voltage and current production of a standalone renewable energy source i.e. a solar panel. This paper also discusses how to improve the solar panel efficiency by correcting the tilt angle of the solar panel. The monitoring of the solar panel is done via an inter-connected system using NodeMCU, Node-RED, Arduino and an MQTT channel. The monitoring of solar panels can be made easier by implementing the proposed work in a photovoltaic (PV) power plant. Moreover, the monitoring of energy production will greatly enhance the health of the PV system. A 24% increase in the power output has been noticed after the correction of the tilt angle which was corrected using a solar tracker.

Vishal S. Patil et.al., "A Review Paper on Solar Power Monitoring System using an IoT"

The solar power monitoring system is used the Internet of Things for the purpose, to overcome the drawbacks of previous solar systems. An IoT is a joint network of the connected devices together and shares the data about how they are used in the environment in which they are operated. The solar power monitoring system is used for generating the electricity by using the energy of sunlight. This system is uses the Arduino Uno for enhancement of the solar systems. This solar power monitoring system uses the Arduino Uno. The Arduino Uno is microcontroller board, this microcontroller used the ATmega328p. ATmega328p is also a microcontroller chip which is developed by Atmel. By using Arduino Uno the solar panel is capable of moving in the direction where sunlight is moves, this is the additional feature of this solar system. This paper shows the working, architecture and connections of the solar power monitoring system using an IoT.

M. Keerthana et.al., "IoT based solar power monitoring system"

Solar power plants need to be monitored for optimum power supply. This helps retrieve efficient power output from power plants while monitoring for faulty solar panels, connections, dust accumulated on panels lowering output and other such issues affecting solar performance. So here we propose an automated IoT based solar power monitoring system that allows for automated solar power monitoring from anywhere over the internet. We use Arduino based system to monitor a 10W solar panel parameters. Therefore, internet of things technology using sensors to monitor the parameters of the solar photovoltaic systems remotely from anywhere using smartphones and computers using web server. In order to achieve it here we propose a sun tracking technology to control the solar panel and rotate it, so it absorbs maximum sunlight every instant. The system is based on a using a IoT monitors and controls the solar photovoltaic system remotely from anywhere around the world. The purpose of the project is to implement a system to continuously track the sun rays with the help of the solar panel and grasping the maximum power from the sun by checking the solar panel according to the sun rays direction with respect voltage sensor and current sensor.

Rajesh Malvi et.al., "A Paper on Solar Power Monitoring System Using IoT"

Renewable energy sources are proven to be reliable and accepted as a good alternative for fulfilling our increasing energy requirement. The user can get the information about the current and previous average parameter like voltage, temperature, current and power saving. Solar photovoltaic energy is the new emerging and enticing clean technologies with zero carbon emission in today's world. This also provide the real time information to the user which will help to monitor the system the main purpose of this paper is that the solar panel can collect, or we can say capture maximum solar radiation and maintain the system more reliably and good. To harness the solar power generation, it is indeed necessary to pay some serious attention to its maintenance as well as application. These IOT based technology is best suitable for remote like areas where solar Power plant are set up due to the large availability of solar energy but regular access to the areas is very much difficult and is not cost efficient.

J. Samuel et.al., "IoT Based Solar Panel Monitoring and Control"

IoT technologies are used to track solar power in this study. On 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.

Vedanti Hardas et.al., "Solar Panel Monitoring System Using IoT"

The invention of the smart grid goes beyond the traditional notion of a one-way power supply. Developed countries have already begun to adopt smart meters, devices, and renewable energy sources. Developing and countries still face power shortages daily. The integration of IoT and energy systems has revolutionized the world in terms of energy efficiency and real-time monitoring. This paper describes an experimental study of how IoT can power the current/ voltage and power generation of self-contained renewable energy sources. Solar modules can be monitored. This document also describes how to modify the tilt angle of the solar panel to improve the efficiency of the solar panel. Solar modules are monitored via a network system with NodeMCU, Atmega328 IC, Arduino. By carrying out the proposed work at a photovoltaic (PV) power plant, you can simplify the monitoring of solar panels. In addition, monitoring power generation can significantly improve the health of PV systems.

Srilakshmi Madadi et.al., "A Study of Solar Power Monitoring System Using Internet of Things (IoT)"

Renewable energy sources are a practical solution for addressing the ongoing supply gap in the power industry. Because of the availability of solar energy throughout the world, unlike other geographically restricted resources, solar energy is most beneficial of all renewable energy resources. Sophisticated frameworks for remote monitoring of the plant using web-based interface is required for this massive scale of solar system deployment. Since the greater part of them are set in areas that are inaccessible and therefore monitoring them is not possible from a specific location. Internet of Things (IoT) enables the objects to be detected and remotely controlled by an established infrastructure of a network, creating possibilities for the pure physical-environment integration into frameworks that are based on computers. Application of IoT is proving beneficial for monitoring renewable energy generation. This application of IoT uses system based on Arduino to monitor parameters of the solar panel. The solar panel is monitored by the system continuously and the power output is transmitted over the internet to the IoT Network. It now uses an effective Interface to display these solar panel parameters to the user and it also alerts user when the outcome falls underneath the cut-off points specified. This makes, distantly monitoring of solar power plants more convenient and the best output of power is guaranteed.

Neelanshi S Palkar et.al., "Solar power monitoring system using IoT"

This paper describes the monitoring of solar power by using internet of thing. The Internet of Things (IoT) refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention. These IoT based technology is best suited for remote areas where solar Power plant is set up due to the ample availability of solar energy but regular access to the areas is very difficult and is not cost efficient. These IoT based technology are comprises of Solar Panel, NODE-MCU ESP8266, Voltage Sensor, Current Sensor, Temperature Senor etc.

Marulasiddappa H et.al., "IoT- Based Solar Power Monitoring"

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.

Sheikh Hasib Cheragee et.al., "A Study of IoT based Real-Time Solar Power Remote Monitoring System"

We have Developed an IoT-based real-time solar power monitoring system in this paper. It seeks an open-source IoT solution that can collect real-time data and continuously monitor the power output and environmental conditions of a photovoltaic panel. The Objective of this work is to continuously monitor the status of various parameters associated with solar systems through sensors without visiting manually, saving time and ensures efficient power output from PV panels while monitoring for faulty solar panels, weather conditions and other such issues that affect solar effectiveness. Manually, the user must use a mustimeter to determine what value of measurement of the system is appropriate for appliance consumers, which is difficult for the larger System. But the Solar Energy Monitoring system is designed to make it easier for users to use the solar system. This system is comprised of a microcontroller (Node MCU), a PV panel, sensors (INA219 Current Module, Digital Temperature Sensor, LDR), a Battery Charger Module, and a battery. The data from the PV panels and other appliances are sent to the cloud (Thingspeak) via the internet using IoT technology and a Wi-Fi module (NodeMCU). It also allows users in remote areas to monitor the parameters of the solar power plant using connected devices. The user can view the current, previous, and average parameters of the solar PV system, such as voltage, current, temperature, and light intensity using a Graphical User Interface. This will facilitate fault detection and maintenance of the solar power plant easier and saves time.

K.G.Srinivasan et.al., "Solar Energy Monitoring System by IoT"

The Internet of Things has a vision in which the internet extends into the real world, which incorporates everyday objects. The IoT allows objects to be sensed or controlled remotely over existing network infrastructure, creating opportunities for pure integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. This technology has many applications like Solar cities, Smart villages, Micro grids and Solar Street lights and so on. As Renewable energy grew at a rate faster than any other time in history during this period. The proposed system refers to the online display of the power usage of solar energy as a renewable energy. This monitoring is done through raspberry pi using flask framework. Smart Monitoring displays daily usage of renewable energy. This helps the user to analysis of energy usage. Analysis impacts on the renewable energy usage and electricity issues.

P. Sampurna Lakshmi et.al., "Solar Panel Fault Detection System using IoT"

The solar parks are now quickly becoming one of the most significant renewable forms of energy systems, hence there is a pressing need for more streamlined use of the aid they provide, as well as error discernment and performance difficulties. The Internet Of Things (IoT) technology attempts to bridge the gap by providing low-priced, modest and long-term results for solar park efficiency. We describe a monitoring and alerting system in this project that is employed in the early identification of Potential Induced Degradation (PID) and Hotspots failures, which can result in a considerable reduction in solar panel performance. Certain practical characteristics like as temperature, voltage, and humidity are continually monitored at the panel level in order to do this. It is mainly focused on the installation of Internet of Things for remote monitoring and performance evaluation of a solar facility. This will make preventative maintenance, solar panel defect detection, and real-time monitoring much easier. Solar towns, smart villages, micro grids, and solar street lighting are just a few of the possibilities for this technology.

Chapter 3

ARCHITECTURE WORKING

3.1 Problem Definition

The widespread adoption of solar energy as a clean and sustainable power source has led to the deployment of solar panel arrays across diverse geographical locations. However, the efficient operation and maintenance of these solar panel's present challenges, including the need for real-time monitoring, fault detection, and performance optimization. Traditional monitoring methods often lack the granularity and immediacy required to address issues promptly, leading to decreased energy output, increased maintenance costs, and potential environmental impact. To address these challenges, there is a need for a comprehensive and intelligent solar panel monitoring system that leverages the capabilities of the Internet of Things (IoT). The current lack of a standardized and scalable IoT solution tailored for solar panel monitoring poses a significant obstacle to maximizing the potential of solar energy. This project aims to develop an integrated IoT-based monitoring system to enable real-time data collection, analysis, and management of solar panel performance, addressing key issues such as:

I. **Fault Detection and Diagnostics:** Existing solar panel monitoring systems often struggle to promptly detect faults or anomalies, leading to reduced energy output and increased downtime. An IoT-based solution should provide real-time fault detection and diagnostics, allowing for swift identification and resolution of issues.

II. **Performance Optimization:** Solar panel efficiency can be impacted by various factors, including shading, dirt accumulation, and environmental conditions. The IoT monitoring system should facilitate continuous performance optimization by collecting and analysing data related to solar irradiance, temperature, and other relevant parameters.

III. **Remote Monitoring and Management:** Solar panel installations are often distributed over large areas, making manual monitoring and management challenging. The proposed IoT solution should enable remote monitoring and management capabilities, allowing operators to access real-time data, configure settings, and perform updates without the need for physical presence at the site.

IV. **Energy Yield Prediction:** Predicting energy yields accurately is crucial for optimizing the overall efficiency of solar panel installations. The IoT-based monitoring system should incorporate predictive analytics to estimate future energy yields based on historical data and environmental conditions.

3.2 Device Lifecycle

Implementing effective device lifecycle and change management is crucial for an IoT-based Solar Panel Monitoring System. Key considerations include:

- **Device Onboarding:** Streamlined processes for adding new devices to the monitoring system ensure efficient integration and deployment, enhancing the overall lifecycle.
- **Configuration Management:** Managing device configurations is vital for optimizing performance. Ensuring proper alignment with solar panels and continuous monitoring helps maintain efficiency.
- **Monitoring and Analytics:** Continuous monitoring and data analytics allow for proactive identification of device issues, enabling timely maintenance and preventing disruptions in the solar panel monitoring system.
- **Integration:** Integrate the solar panel monitoring system with the actual solar panel setup. Ensure proper connectivity between sensors, microcontrollers, and the cloud. Validate the system's performance under real-world conditions.
- **Operation:** Monitor the solar panel system in real-time through the user interface. Collect and analyse data to ensure optimal performance and energy production.

3.3 Architecture Overview

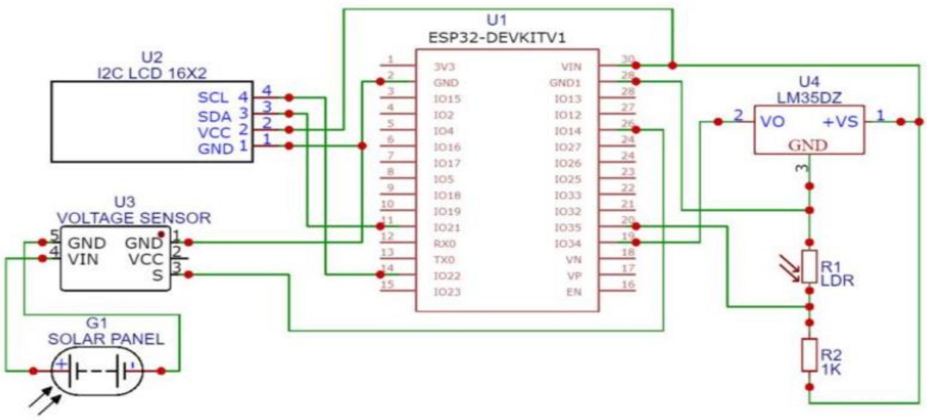

Fig. 3.1 Circuit Diagram of the Device

This architecture combines hardware components (ESP32, sensors, LCD, solar panel) with software (firmware for ESP32, cloud platform) to create a smart system that collects, displays, and transmits data from various sensors to the cloud.

Chapter 4

METHODOLOGY

4.1 Block Diagram

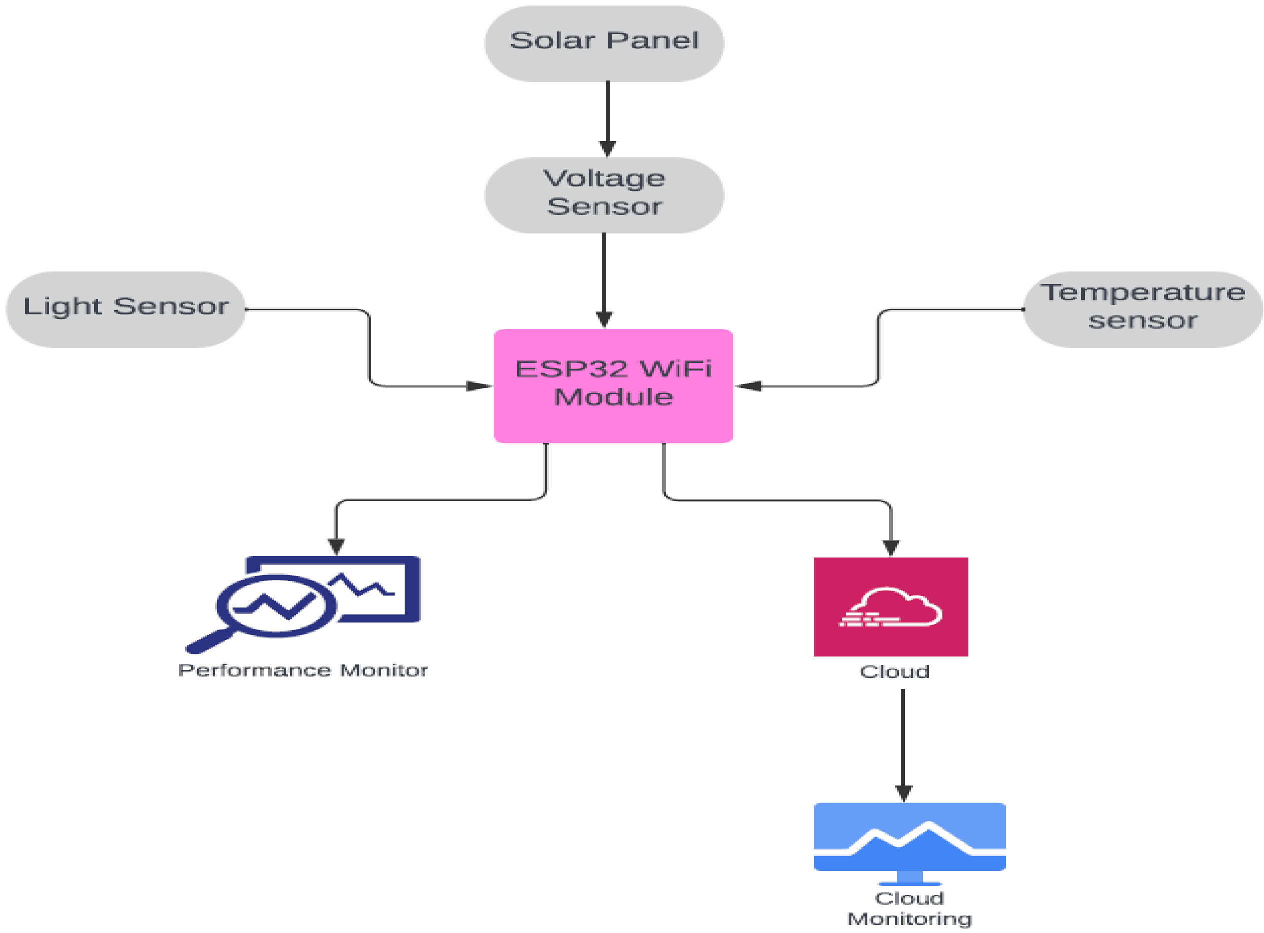

Fig 4.1 Block Diagram of System

The system revolves around an ESP32 Wi-Fi module serving as the central hub, intricately connected to an LCD display, a voltage sensor, a light sensor, a temperature sensor. This integrated setup aims to collect comprehensive data from the sensors, providing a real-time display on the connected LCD while simultaneously transmitting this information to the cloud.

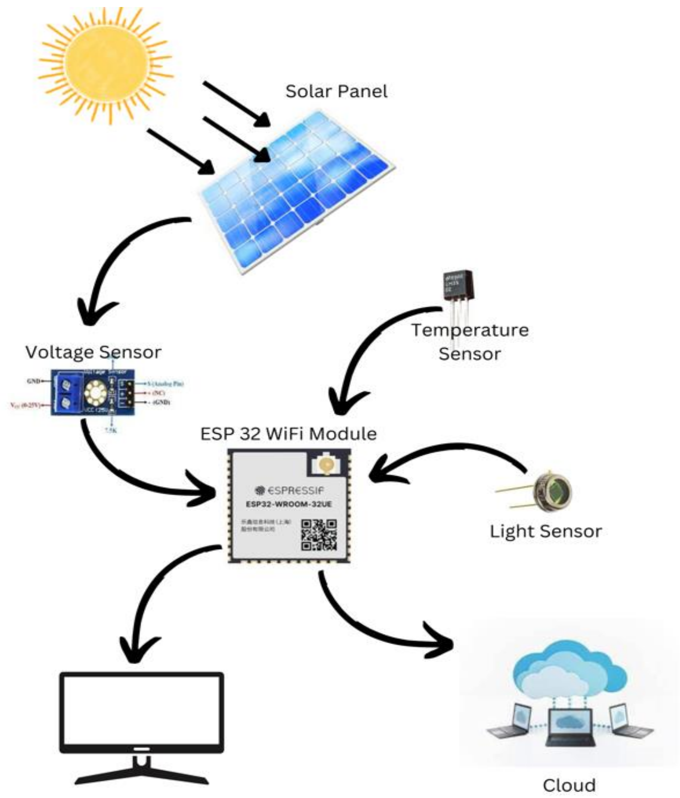

Fig. 4.2 Graphical Representation of the System

4.2 System Specifications

The ESP32, acting as the main microcontroller, orchestrates the data acquisition process, reading inputs from the voltage, light, and temperature sensors, and monitoring the output of the solar panel. Through intricate data processing, the ESP32 optimizes and refines the collected information before presenting it on the local LCD display for immediate user insight. Simultaneously, the ESP32 establishes a secure connection to the internet via Wi-Fi, facilitating the seamless transfer of processed data to the cloud. This cloud platform, such as AWS IoT or Google Cloud IoT, becomes the repository for historical data, allowing remote users to monitor, analyse, and visualize the solar panel system's performance through a user-friendly dashboard. The system, enriched by security measures and power management considerations, offers a holistic solution for efficient solar panel monitoring, combining local visibility with remote accessibility and analysis.

4.3 Hardware Configuration

Processor	Intel i5
Monitor	16x2 I2C LCS Display
Sensors	Voltage Sensor Module, LM35 Temperature Sensor, LDR
Solar Panel	(3-25V)
Zero PCB	

4.4 Software Configuration

Operating System	Windows 11
Language	Embedded C
Cloud	ThingSpeaks

EXPECTED OUTCOME

- The system showcases the solar voltage produced by the solar panel, and this information is displayed on the LCD screen.
- The displayed data is derived from measurements taken by the sensors, ensuring accuracy and real-time representation.
- Concurrently, the system generates a graphical output on a cloud server, making the information accessible on a global scale.
- Users have the capability to access this solar voltage data from any location, providing a convenient and remote overview.
- The comprehensive presentation is facilitated through both the local LCD screen and the cloud-based interface, allowing users to monitor the solar voltage efficiently.

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