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SOLAR TRACKING SYSTEM WITH ARDUINO AND IOT-BASED BATTERY MONITORING USING ESP8266

[1st]Arem Satish Kumar Reddy, [2nd]M Prudvhi, [3rd]N Rama Sai, [4th]D Narasimha

[1 st] B.Tech Author, [2nd] B.Tech Author, [3rd] B.Tech Author, [4th] B.Tech Author
Electrical and Electronics Engineering,
Chadalawada Ramanamma Engineering College, Tirupati, India

ABSTRACT

Our project integrates a Solar Tracking System (STS) with IoT-based Battery Monitoring using Arduino and ESP8266, leveraging the ThingSpeak IoT platform. The STS optimizes solar panel orientation by tracking the sun's position throughout the day, managed by Arduino Uno with light sensors and servo motors for precise alignment. Augmented with IoT-based Battery Monitoring, the system ensures enhanced reliability and remote management. ESP8266 facilitates wireless communication, transmitting real-time battery data to ThingSpeak's cloud platform. Users can monitor battery health, charge levels, and receive alerts for maintenance needs. This integration empowers users to remotely optimize system performance and ensure uninterrupted energy supply. ThingSpeak's intuitive interface allows easy access to vital system metrics, facilitating efficient energy management. This research introduces a smart automation solution employing a two-channel relay, controllable via the Blynk mobile app, facilitating remote operation and automation of electrical devices for enhanced convenience and energy efficiency in modern living spaces.

INTRODUCTION

In an era marked by increasing environmental concerns and the quest for sustainable energy sources, solar power has emerged as a beacon of hope. Its abundance and renewability offer a promising alternative to traditional fossil fuels, yet harnessing solar energy efficiently remains a challenge. The dynamic nature of sunlight and the need for effective energy storage solutions call for innovative approaches that maximize energy capture while ensuring system reliability and longevity. In response to these challenges, our project focuses on the integration of two cutting-edge technologies: Solar Tracking Systems (STS) and IoT-based Battery Monitoring, leveraging ESP8266

modules and orchestrated through the powerful ThingSpeak IoT platform.Solar energy's ascent to prominence as a viable alternative to conventional energy sources is undeniable. However, the optimal utilization of this abundant resource hinges on addressing key challenges such as maximizing energy capture and ensuring effective battery management. The integration of Solar Tracking Systems with IoT-based Battery Monitoring represents a transformative approach to addressing these challenges comprehensively. Solar Tracking Systems dynamically adjust the orientation of solar panels to align with the sun's position throughout the day, optimizing energy capture. By implementing a Solar Tracking System powered by Arduino, equipped with light sensors and servo motors, our project ensures real-time adjustments to panel angles, maximizing solar energy yield. Furthermore, ensuring the reliability and efficiency of solar energy systems necessitates robust battery management. Here, IoT-based Battery Monitoring plays a pivotal role, leveraging ESP8266 modules to wirelessly transmit crucial battery health and charge status data to the cloud. Leveraging the capabilities of the ThingSpeak platform, users gain remote access to this data, enabling proactive maintenance and troubleshooting while receiving timely alerts for any potential issues. The integration of solar tracking and IoT-based battery monitoring signifies a significant advancement in sustainable energy management. By seamlessly combining these technologies, our project aims to demonstrate how leveraging the ThingSpeak platform can enhance the efficiency, reliability, and accessibility of solar energy systems, contributing to a greener and more sustainable future. In the following sections, we will delve into the technical intricacies of our project, detailing the implementation of Solar Tracking Systems, IoT-based Battery Monitoring, and the integration with the ThingSpeak IoT platform. Furthermore, we will explore the potential benefits of this integration in advancing sustainable energy solutions and mitigating the environmental impact of energy consumption. With the rapid advancement of technology, smart automation systems have become increasingly prevalent in various aspects of our daily lives. One such application is the use of IoT (Internet of Things) devices to control and monitor electronic appliances remotely. In this project, we focus on the development of a smart automation system using a 2-channel relay controlled through the Blynk mobile application. The Blynk app provides a user-friendly interface for controlling IoT devices over the internet, making it an ideal platform for implementing home automation solutions. By integrating Blynk with a 2-channel relay module, users can remotely switch on or off electrical appliances such as lights, fans, or other devices connected to the relay. In this introduction, we will provide an overview of the project objectives, the components used, and the expected benefits of implementing this smart automation system. Additionally, we will outline the structure of the following sections, which will delve into the details of the project implementation and functionality.

1.1 EMBEDDED SYSTEMS

Embedded systems play a crucial role in the implementation of Solar Tracking and IoT Battery Monitoring in conjunction with ESP8266 modules on the ThingSpeak platform. These systems are responsible for the seamless integration of hardware components, data processing, communication, and control functionalities. In the context of our project, embedded systems facilitate the following key aspects:

1. **Hardware Integration**: Embedded systems, typically based on microcontrollers like Arduino Uno, serve as the central processing units that interface with various hardware components. For solar tracking, embedded systems control servo motors to adjust panel angles based on real-time sensor data. Similarly, for IoT-based battery monitoring, they interface with battery sensors and ESP8266 modules to collect and transmit battery-related data to the cloud.

2. **Real-time Control and Decision Making**: Embedded systems execute control algorithms for solar tracking, continuously adjusting panel angles to maximize energy capture based on sensor inputs. These systems perform real-time calculations to determine optimal panel orientations relative to the sun's position. Additionally, they implement logic for battery monitoring, such as voltage and temperature thresholds, to trigger alerts or adjust system parameters as necessary.

3. **Data Processing and Communication**: Embedded systems process sensor data and format it for transmission to the ThingSpeak cloud platform via ESP8266 modules. They handle communication protocols such as Wi-Fi to establish connectivity with ThingSpeak servers, ensuring seamless data transmission and synchronization with the cloud. Furthermore, these systems may preprocess data locally to reduce bandwidth requirements or perform basic analytics before uploading to the cloud.

4. **Remote Monitoring and Control:** Embedded systems enable remote monitoring and control of the solar tracking and battery monitoring systems through ThingSpeak's web interface or mobile applications. Users can access real-time data, receive alerts, and adjust system parameters remotely, enhancing system accessibility and enabling proactive maintenance.

Overall, embedded systems serve as the backbone of the Solar Tracking and IoT Battery Monitoring solution, providing the intelligence and control necessary to optimize energy capture, ensure system reliability, and enable remote management via the ThingSpeak platform. Through the seamless integration of hardware and software components, embedded systems play a vital role in advancing sustainable energy solutions.

1.2 APPLICATION AREAS

The integration of Solar Tracking and IoT Battery Monitoring with ESP8266 modules on the ThingSpeak platform opens up a wide range of application areas where these technologies can be deployed effectively. Some key application areas include:

1. **Residential Solar Power Systems:** Homeowners can utilize solar tracking systems coupled with IoT-based

battery monitoring to optimize energy production and storage. By tracking the sun's movement and monitoring battery health remotely, homeowners can maximize energy self-sufficiency, reduce electricity bills, and contribute to a greener environment.

2. **Commercial and Industrial Facilities**: Businesses and industrial facilities can deploy solar tracking systems integrated with IoT-based battery monitoring to reduce energy costs and enhance sustainability. These systems can be scaled up to meet higher energy demands, providing reliable power for manufacturing processes, office buildings, warehouses, and more.

3. **Off-Grid Applications**: Solar tracking and IoT battery monitoring are particularly valuable in off-grid or remote locations where access to traditional power sources is limited. Applications such as off-grid cabins, remote monitoring stations, telecommunications infrastructure, and agricultural operations can benefit from reliable solar energy generation and battery storage, coupled with remote monitoring capabilities.

4. **Smart Agriculture**: Solar-powered IoT systems can be deployed in agriculture for various purposes, including irrigation control, environmental monitoring, and precision agriculture. Solar tracking enables efficient energy capture for powering sensors and actuators in the field, while IoT-based battery monitoring ensures continuous operation and data collection.

5. **Environmental Monitoring and Research**: Solar-powered IoT systems can be used for environmental monitoring and research applications, such as weather stations, air quality monitoring, and wildlife tracking. Solar tracking ensures optimal energy capture for powering sensors and transmitting data, while IoT-based battery monitoring ensures uninterrupted operation in remote or harsh environments.

6. **Emergency Response and Disaster Management**: Solar-powered IoT systems can serve as resilient communication and monitoring platforms in emergency response and disaster management scenarios. These systems can be deployed quickly in affected areas to provide power, communication, and situational awareness, facilitating coordinated response efforts and improving disaster resilience.

7. **Education and Research**: Solar tracking and IoT battery monitoring systems provide valuable educational opportunities for students and researchers to learn about renewable energy, electronics, data analytics, and IoT technologies. These systems can be used in educational institutions and research laboratories for hands-on learning and experimentation.

Overall, the application areas for Solar Tracking and IoT Battery Monitoring with ESP8266 modules are diverse and encompass a wide range of industries and use cases. By leveraging these technologies, organizations and individuals can achieve greater energy efficiency, reliability, and sustainability in various domains.

1.3 Over view of Embedded system Architecture

The embedded system architecture for Solar Tracking and IoT Battery Monitoring with ESP8266 modules encompasses hardware components, software algorithms, communication protocols, and cloud integration. Here's an overview of the architecture:

1. **Hardware Components:**

- Microcontroller (e.g., Arduino Uno): Acts as the central processing unit and interfaces with sensors, actuators, and ESP8266 modules.
- Sensors: Light sensors for solar tracking, battery sensors for monitoring voltage, current, and temperature.
- Actuators: Servo motors for adjusting solar panel angles.
- ESP8266 Module: Enables Wi-Fi connectivity for communication with the ThingSpeak cloud platform.

2. **Software Algorithms:**

- Solar Tracking Algorithm: Determines optimal solar panel orientation based on real-time input from light sensors and the sun's position.
- Battery Monitoring Algorithm: Monitors battery health and charge status, triggers alerts for low voltage or critical conditions.
- Communication Protocol: Implements protocols such as Wi-Fi (for ESP8266 communication) and HTTP/HTTPS (for cloud communication) to transmit data.

3. **Communication and Connectivity:**

- Local Communication: Microcontroller communicates with sensors, actuators, and ESP8266 module using standard communication interfaces such as I2C, SPI, or UART.
- Wireless Communication: ESP8266 module establishes Wi-Fi connectivity to transmit data to the ThingSpeak cloud platform.
- Cloud Integration: Data is transmitted securely to the ThingSpeak cloud platform using HTTP/HTTPS protocols, where it is stored, processed, and made accessible for remote monitoring and analysis.

4. **Cloud Platform (ThingSpeak):**

- Data Storage: ThingSpeak stores sensor data in channels, allowing for easy retrieval and analysis.
- Visualization: Provides customizable charts, graphs, and dashboards to visualize real-time and historical data.
- Alerts and Notifications: Allows users to set up alerts based on predefined thresholds for battery voltage,

solar panel efficiency, or other parameters.

➢ Remote Access: Users can remotely monitor system status, adjust settings, and receive notifications via web interface or mobile applications.

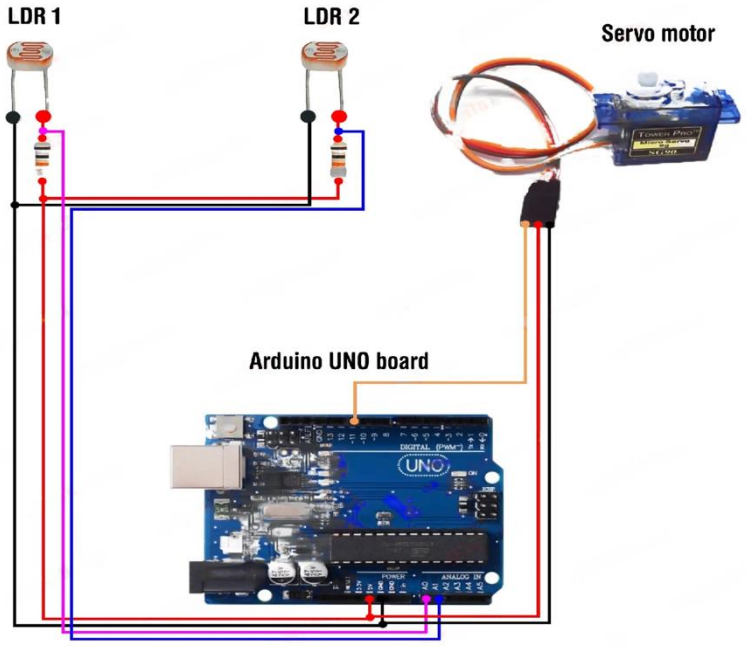
5. **User Interface:**

➢ Web Interface: ThingSpeak provides a user-friendly web interface for accessing and managing data, setting up alerts, and visualizing system performance.

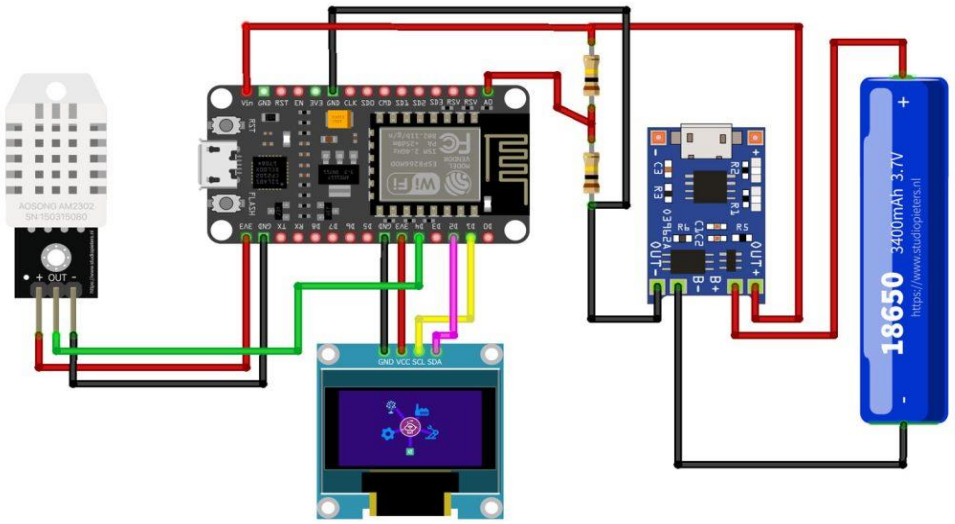
➢ Mobile Applications: ThingSpeak offers mobile applications for iOS and Android devices, allowing users to monitor and control the system remotely.

1.4 Embedded Block Diagram

Circuit Diagram Solar Tracking System (STS) using Arduino



Circuit Diagram IoT-based Battery Monitoring using ESP8266



1.4 Application of Embedded System

1. **Home Solar Energy Systems:**

➢ Powering homes with solar energy while efficiently tracking the sun's movement for optimal energy capture.

➢ Monitoring battery health and charge status to ensure uninterrupted power supply, reducing reliance on the grid.

2. **Smartphone Charging Stations:**

➢ Setting up solar-powered charging stations for smartphones and other portable devices in parks, public spaces, or outdoor events.

➢ Using IoT battery monitoring to manage charging cycles and ensure availability of charged devices.

3. **Outdoor Lighting Solutions:**

➢ Illuminating pathways, gardens, and outdoor spaces with solar-powered lights that adjust brightness based on available sunlight.

➢ Monitoring battery levels to ensure continuous lighting throughout the night, enhancing safety and security.

4. **Solar-Powered Garden Accessories:**

➢ Installing solar-powered water features, garden lights, and decorative accessories that automatically adjust to capture sunlight efficiently.

➢ Monitoring battery status to ensure optimal performance and longevity of garden accessories.

5. **Portable Solar Chargers:**

- Using portable solar chargers equipped with IoT battery monitoring for charging smartphones, tablets, and other electronic devices while on the go.
- Monitoring battery levels and charging status to optimize device charging and extend battery lifespan.

6. **Outdoor Recreational Equipment:**

- Incorporating solar-powered features into outdoor recreational equipment such as backpacks, tents, and camping gear.
- Monitoring battery levels to ensure reliable performance of equipment during outdoor activities and adventures.

7. **Smart Home Automation:**

- Integrating solar tracking and IoT battery monitoring into smart home automation systems to optimize energy usage and reduce utility costs.
- Controlling home appliances, lighting, and climate control systems based on real-time energy availability and battery status.

8. **Solar-Powered Wearable Technology:**

- Developing wearable devices, such as smartwatches and fitness trackers, with integrated solar panels for continuous charging.
- Utilizing IoT battery monitoring to optimize power consumption and manage charging cycles for wearable technology.

1.5 Characteristics

1. **Efficiency Optimization:**

- Solar tracking adjusts panel angles to maximize energy capture from sunlight throughout the day.
- IoT battery monitoring ensures efficient use of stored energy, prolonging battery life and optimizing power usage.

2. **Remote Monitoring and Control:**

- ESP8266 modules enable wireless communication, allowing users to monitor and control solar tracking and battery systems remotely.
- Users can access real-time data, receive alerts, and adjust system settings via web interfaces or mobile applications.

3. **Reliability and Resilience:**

- Solar tracking and IoT battery monitoring enhance system reliability by ensuring continuous power supply and proactive maintenance.
- These systems provide resilience against grid outages, enabling uninterrupted operation in off-grid or remote locations.

4. **Data-driven Insights:**

- Solar tracking and IoT battery monitoring collect and analyze data on energy production, consumption, and battery health.
- Users gain valuable insights into system performance, enabling informed decision-making and optimization of energy resources.

5. **Scalability and Flexibility:**

- Solar tracking and IoT battery monitoring solutions can be scaled up or down to meet varying energy demands and system requirements.
- They offer flexibility in deployment across different applications, from residential homes to commercial facilities and off-grid installations.

6. **Integration with IoT Ecosystem:**

- ESP8266 modules seamlessly integrate solar tracking and battery monitoring systems into the broader IoT ecosystem.
- They enable interoperability with other IoT devices and platforms, facilitating data sharing, analytics, and automation.

These characteristics underscore the versatility, efficiency, and reliability of Solar Tracking and IoT Battery Monitoring with ESP8266 modules, making them essential components of modern energy management systems.

CHAPTER 2: LITERATURE SURVEY

2.1 Literature Survey

A literature survey on Solar Tracking and IoT Battery Monitoring with ESP8266 encompasses a comprehensive review of existing research, studies, and projects in the field. Solar tracking systems, aimed at maximizing energy capture by aligning solar panels with the sun's position, are explored along with IoT-based battery monitoring systems, which facilitate real-time monitoring of battery health and performance. These systems are crucial for enhancing the efficiency and reliability of solar energy systems. The survey delves into various solar tracking techniques, including single-axis and dual-axis tracking, evaluating their accuracy, complexity, and cost-effectiveness. Similarly, IoT-based battery monitoring systems are examined, focusing on sensor technologies, communication protocols, and data analytics methods used for battery health monitoring. Integration of ESP8266 modules, renowned for their wireless communication capabilities, with the ThingSpeak IoT platform is highlighted as a pivotal aspect of system implementation, enabling remote access, data storage, and visualization. Case studies showcasing real-world applications of Solar Tracking and IoT Battery Monitoring systems in residential, commercial, and industrial settings provide insights into system deployment and performance. The survey concludes with discussions on challenges such as system complexity and scalability, as well as future research directions to further advance the field. Through this literature survey, researchers can gain a comprehensive understanding of the current state of the art and identify avenues for future research and innovation in Solar Tracking and IoT Battery Monitoring with ESP8266.

2.2 Existing System

The existing system for Solar Tracking and IoT Battery Monitoring with ESP8266 involves a combination of traditional solar tracking mechanisms and standalone battery monitoring systems. Typically, solar tracking systems utilize sensors to detect sunlight intensity and adjust solar panel angles accordingly, optimizing energy capture throughout the day. These systems may operate independently of battery monitoring, relying on manual or periodic checks to ensure battery health and performance.Similarly, standalone battery monitoring systems utilize sensors to measure parameters such as voltage, current, and temperature, providing insights into battery health and charge status. However, these systems may lack integration with solar tracking mechanisms, limiting their ability to optimize energy usage and battery performance in real time. While both solar tracking and battery monitoring systems serve essential functions in maximizing energy efficiency and system reliability, the lack of integration can result in suboptimal performance and increased maintenance efforts. Users may need to manually adjust solar panel angles based on weather conditions or battery status, leading to potential energy wastage or downtime. Overall, the existing system comprises separate components for solar tracking and battery monitoring, with limited integration and automation capabilities. There is a need for a more cohesive and integrated solution that combines solar tracking and battery monitoring functionalities, leveraging ESP8266 modules and IoT technologies for seamless communication, remote monitoring, and intelligent control.

CHAPTER 3: IMPLEMENTATION

3.1 Proposed System

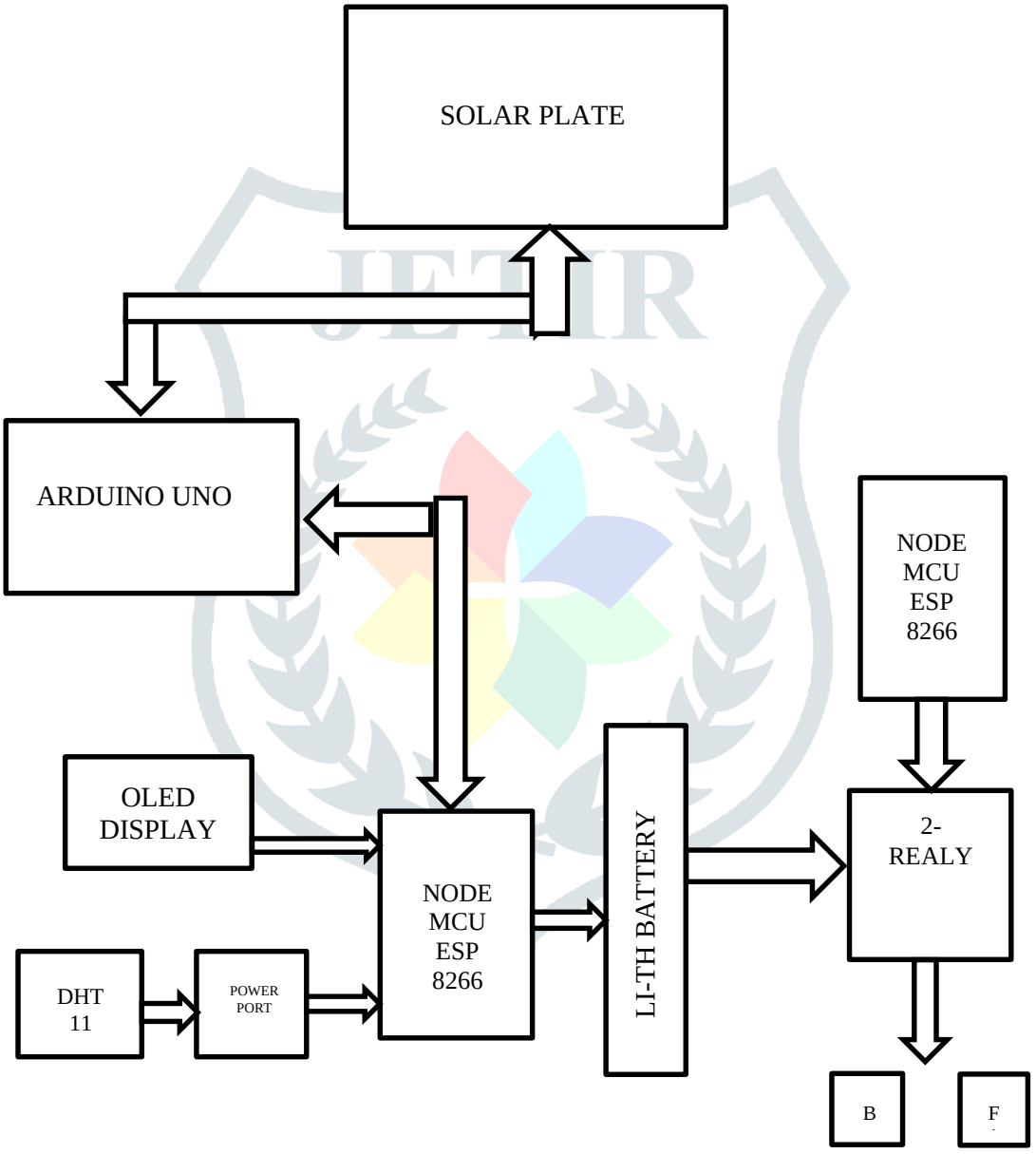
The proposed system for Solar Tracking and IoT Battery Monitoring with ESP8266 presents a comprehensive and integrated approach aimed at overcoming the limitations observed in existing systems. At its core, this system combines the functionalities of solar tracking technology and IoT-based battery monitoring, harmonizing them through the utilization of ESP8266 modules, renowned for their capabilities in facilitating seamless communication and control. The solar tracking component of the system operates dynamically, continuously adjusting the angles of solar panels to optimize energy capture by aligning them with the sun's position throughout the day. This process is facilitated by sophisticated algorithms that account for various environmental factors such as the sun's trajectory, weather conditions, and potential shading. Concurrently, the IoT-based battery monitoring aspect ensures the real-time monitoring of crucial battery health and performance parameters. These parameters include voltage, current, temperature, and other relevant metrics. This data is then wirelessly transmitted to the cloud infrastructure via ESP8266 modules, enabling remote access, analysis, and visualization. Integral to the system's functionality is its integration with the ThingSpeak IoT platform. This platform serves as the backbone for data storage, visualization, and remote management. It facilitates the seamless transmission and storage of solar tracking and battery monitoring data, while also providing a user-friendly interface for accessing system metrics, trends, and alerts. Moreover, the proposed system boasts sophisticated automatic control algorithms, which optimize energy consumption and battery charging cycles in real time. This ensures not only maximum energy efficiency but also extends the longevity of the battery system. Ultimately, the user-friendly interface empowers users to effortlessly manage the system, whether through web browsers or mobile applications. Visualization tools within the interface provide insightful analytics on energy production, consumption patterns, and battery health trends. In summary, the proposed system stands as a testament to the evolution of solar energy management, offering a comprehensive, intelligent, and user-centric solution that enhances efficiency, reliability, and sustainability across diverse applications and settings.

3.2 Objective of the Proposed System

The primary objective of the proposed system for Solar Tracking and IoT Battery Monitoring with ESP8266 is to develop a cohesive and integrated solution that addresses key challenges in solar energy management. At its core, the system aims to optimize energy capture from solar panels by dynamically adjusting their angles to align with the sun's position throughout the day. This optimization is facilitated through the implementation of advanced solar tracking algorithms, which seek to maximize energy production while minimizing wastage. Additionally, the system endeavors to continuously monitor the health and performance of the battery system using IoT-based sensors. By measuring parameters such as voltage, current, and temperature in real-time, the system can assess battery condition, detect anomalies, and ensure optimal operation. Moreover, the integration of ESP8266 modules and the ThingSpeak IoT platform enables remote monitoring and control capabilities, allowing users to access system data, receive alerts for critical events, and adjust settings from anywhere via web interfaces or mobile applications. This remote accessibility enhances convenience and enables proactive maintenance, ultimately contributing to increased system reliability and sustainability. Lastly, the system prioritizes user experience by

providing a user-friendly interface for system management, complete with visualization tools and intuitive controls, empowering users to monitor performance, analyze data trends, and make informed decisions effectively. Overall, the objective of the proposed system is to create a robust, efficient, and user-centric solution for optimized solar energy management.

3.2.2 Block Diagram



3.3 Methodology

The methodology for implementing the proposed system of Solar Tracking and IoT Battery Monitoring with ESP8266 follows a systematic approach to ensure successful development, integration, and deployment. Initially, a comprehensive analysis of system requirements is conducted, considering factors such as energy production goals, site conditions, and user preferences. This analysis guides the selection of appropriate hardware components, including solar panels, sensors, and ESP8266 modules, and informs the design of the overall system architecture. Software development involves the creation of algorithms for solar tracking, IoT-based battery monitoring, and user interfaces for remote monitoring and control. Integration of hardware and software components is followed by rigorous testing to validate system functionality and performance under various conditions. Upon deployment, optimization efforts focus on maximizing energy efficiency and reliability through parameter tuning and user training. Continuous monitoring and maintenance procedures are established to ensure long-term system reliability, with ongoing evaluation and feedback informing iterative improvements and enhancements. Through this methodology, the proposed system aims to deliver efficient, reliable, and user-friendly solar energy management capabilities for various applications and environments.

3.4 Web Monitoring

Web monitoring encompasses the systematic tracking and analysis of website performance, availability, and functionality to ensure optimal user experience and maintain the overall health of online platforms. This process involves defining clear objectives for monitoring, such as uptime, response time, and user interactions, and selecting appropriate tools and technologies to collect and analyze relevant data. Monitoring agents or probes are deployed strategically to simulate user interactions, monitor server performance, and gather data on website availability and response times. The collected data is then analyzed to identify trends, patterns, and anomalies, with a focus on key performance indicators like page load times, server response times, and error rates. Alerting mechanisms are configured to notify stakeholders of any detected issues or performance degradation, enabling timely response and resolution. Additionally, web monitoring facilitates performance optimization efforts by providing insights into areas for improvement, such as code optimization, server configuration, and content delivery network optimization. Continuous monitoring and iterative improvement processes ensure that websites and web applications consistently deliver optimal performance and user satisfaction over time. Through effective web monitoring practices, organizations can proactively identify and address issues, ultimately enhancing the overall user experience and maximizing the value of their online presence.

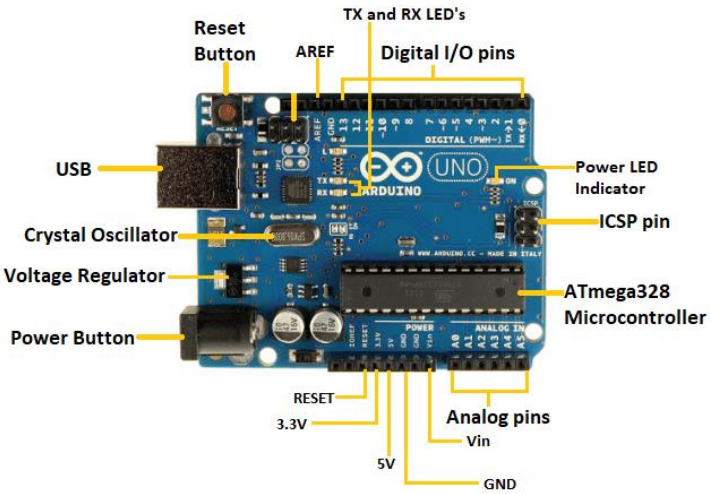
3.5 Requirements

The requirements for Solar Tracking and IoT Battery Monitoring with ESP8266 encompass a multifaceted approach to ensuring the system's functionality, performance, and user experience. Central to these requirements is the need for accurate solar tracking functionality, achieved through the implementation of precise algorithms that dynamically adjust solar panel angles in response to the sun's position. Concurrently, IoT-based battery monitoring must be seamlessly integrated, employing sensors to monitor critical parameters like voltage and temperature in real-time, while enabling wireless communication with ESP8266 modules for data transmission. Integration with cloud platforms such as ThingSpeak is essential, facilitating remote access, data storage, and visualization for users

via intuitive interfaces accessible from web browsers or mobile devices. Reliability and robustness are paramount, necessitating error handling mechanisms and rigorous testing to ensure system stability under varying environmental conditions. Additionally, scalability and flexibility are crucial, allowing for system expansion and compatibility with diverse battery and solar panel configurations. Energy efficiency optimization further enhances system performance, minimizing power consumption while maximizing energy capture and battery lifespan. By addressing these requirements comprehensively, the Solar Tracking and IoT Battery Monitoring system with ESP8266 can deliver efficient, reliable, and user-centric energy management solutions across a range of applications and settings.

CHAPTER 4: HARDWARE TOOLS

4.1 Ardunio UNO



The Arduino Uno microcontroller board stands as a pivotal component in the implementation of Solar Tracking and IoT Battery Monitoring systems with ESP8266, offering a versatile and user-friendly platform for developing and controlling intricate electronics projects. Equipped with an Atmega328P microcontroller, the Arduino Uno serves as the central processing unit, orchestrating the interactions between various hardware components. Its abundant digital and analog input/output pins facilitate seamless interfacing with a diverse array of sensors, including those essential for solar tracking and battery monitoring. Additionally, the Arduino Uno's capability to generate pulse width modulation (PWM) signals enables precise control over servo motors, facilitating accurate adjustments to solar panel angles for optimal alignment with the sun. Furthermore, the Arduino Uno communicates effortlessly with ESP8266 modules through serial communication protocols, allowing for wireless transmission of sensor data to cloud platforms or remote servers. This communication facilitates real-time monitoring and analysis of critical parameters, ensuring the system's efficiency and reliability. Programmed using the Arduino Integrated Development Environment (IDE), the Arduino Uno offers an accessible platform for firmware development, empowering developers to implement complex algorithms and functionalities tailored to the project's requirements. In essence, the Arduino Uno serves as the backbone of Solar Tracking and IoT Battery Monitoring systems, providing the computational power, interfacing capabilities, and flexibility necessary to realize the project's objectives effectively.

The Arduino Uno has a total of 14 digital input/output pins and 6 analog input pins. Here's a breakdown of the functions and common uses of each pin:

1. Digital Pins (D0-D13)

- D0 to D13: These are digital input/output pins. They can be used for reading digital inputs (like switches, sensors) or outputting digital signals (like controlling LEDs, relays).
- D0 (RX) and D1 (TX): These pins are also used for serial communication (UART). RX is for receiving data, and TX is for transmitting data.

- D2 and D3: These pins support interrupt capability. They can be used to trigger an interrupt routine based on a change in state.
- D3, D5, D6, D9, D10, and D11: These pins support PWM (Pulse Width Modulation), allowing you to simulate analog output by varying the duty cycle of the signal.
- D4 and D7: These pins are not commonly highlighted for specific features but can be used as general-purpose digital pins.

2. Analog Pins (A0-A5)

- A0 to A5: These pins are analog input pins. They can read analog voltages from sensors or other devices. They can also be used as digital pins (A0 as D14, A1 as D15, and so on).

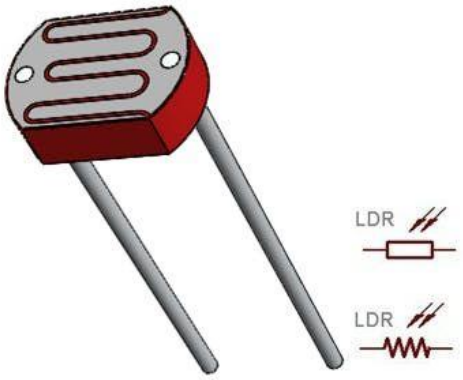
3. Power and Ground Pins

- 5V and 3.3V: These pins provide regulated power supply at 5 volts and 3.3 volts respectively.
- GND (Ground): These pins are connected to the ground of the system.

4. Other Pins:

- RESET: This pin is used to reset the microcontroller.
- AREF: Stands for Analog Reference. It is used to provide an external reference voltage for the analog inputs.

4.2 LDR Light Sensor



The LDR (Light Dependent Resistor) light sensor plays a pivotal role in Solar Tracking and IoT Battery Monitoring systems with ESP8266, acting as a key component for detecting ambient light changes crucial for solar tracking functionality. Functioning on the principle of altering its resistance in response to varying light intensity, the LDR provides real-time feedback on environmental illumination levels. Integrated with microcontroller boards like the Arduino Uno, the LDR sensor serves as a sensing module, interfacing with analog input pins to convert light variations into measurable voltage or resistance changes. This data acquisition enables the microcontroller to continually assess the current light conditions, essential for optimizing solar panel orientation to maximize energy capture throughout the day. By monitoring the resistance or voltage output from the LDR sensor, the microcontroller generates precise control signals necessary for adjusting servo motors responsible for aligning solar panels with the sun's position. Furthermore, calibration and optimization processes may be employed to fine-tune the sensor's sensitivity and responsiveness, ensuring accurate solar tracking performance. Ultimately, the integration of the LDR light sensor enhances the system's capability to dynamically adapt to changing light conditions, significantly improving energy efficiency and overall performance in solar energy harvesting applications.

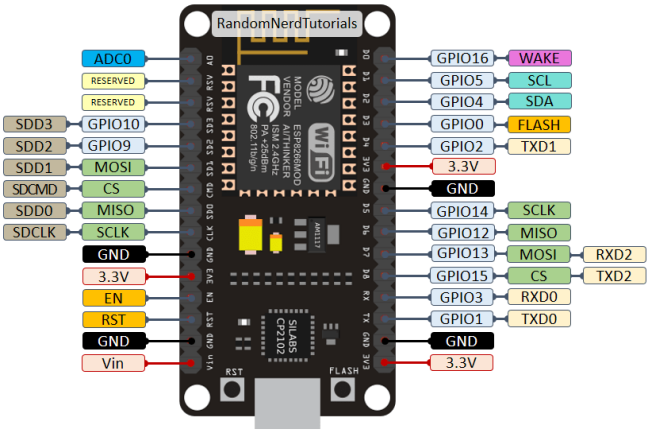
4.3 Servo Motor

The servo motor serves as a crucial component within Solar Tracking and IoT Battery Monitoring systems, particularly in the context of adjusting the orientation of solar panels for optimal energy capture. Functioning as the mechanical actuator responsible for aligning the panels with the sun's position, the servo motor receives control signals from the system's microcontroller, typically an Arduino Uno. These signals, often in the form of pulse width modulation (PWM), dictate the precise angle of rotation required to maintain alignment with the sun's trajectory throughout the day. In response, the servo motor executes these commands, ensuring the solar panels continuously face the sun to maximize energy output. Furthermore, some servo motors feature position feedback mechanisms, providing real-time information on their current orientation. This feedback loop enables the microcontroller to fine-tune the positioning of the solar panels, compensating for any deviations and optimizing energy capture efficiency. With their efficient power consumption, durability, and reliability, servo motors are well-suited for outdoor applications and can withstand the environmental challenges inherent in solar tracking systems. Overall, the servo motor's integral role in facilitating precise and responsive adjustments to solar panel orientation contributes significantly to the overall effectiveness and efficiency of Solar Tracking and IoT Battery Monitoring systems.

4.4 Solar Board

The solar board, a vital component within Solar Tracking and IoT Battery Monitoring systems with ESP8266, stands as the primary mechanism for harnessing solar energy. Employing the photovoltaic effect, it converts sunlight into electrical energy through arrays of interconnected solar cells. These panels vary in size, efficiency, and capacity, offering flexibility to tailor energy generation to specific project requirements. Integrated within the solar tracking system, the solar board dynamically adjusts its orientation to align with the sun's position, optimizing energy capture throughout the day. This dynamic alignment enhances overall system efficiency by ensuring maximum exposure to sunlight. Furthermore, the electrical output from the solar board serves as the power source for the battery monitoring system, charging rechargeable batteries and sustaining the operation of IoT components. With their robust construction and weather-resistant design, solar boards withstand various environmental conditions, ensuring long-term reliability and performance. Additionally, their scalability allows for easy expansion to meet evolving energy demands. While requiring minimal maintenance, periodic cleaning and inspections ensure continued efficiency and operation. In essence, the solar board epitomizes the renewable energy ethos of Solar Tracking and IoT Battery Monitoring systems, serving as a dependable source of clean energy while facilitating efficient system operation and sustainability.

4.5 ESP8266 WIFI Module



The ESP8266 WiFi module is a crucial component within Solar Tracking and IoT Battery Monitoring systems with ESP8266, enabling wireless connectivity and communication capabilities essential for remote monitoring and control. Serving as the bridge between the system's sensors, microcontroller, and cloud platforms, the ESP8266 module facilitates the transmission of data over WiFi networks. Equipped with built-in TCP/IP protocol stack, this module offers reliable and secure communication channels, ensuring seamless data exchange between the system's components and external servers or cloud platforms. Integrated with the Arduino Uno or other microcontroller boards, the ESP8266 module receives sensor data, battery status information, and system alerts, transmitting them wirelessly to cloud-based IoT platforms such as ThingSpeak. This enables users to remotely monitor system performance, access real-time data, and receive timely notifications via web interfaces or mobile applications. Furthermore, the ESP8266 module supports bidirectional communication, allowing users to send control commands to the system for adjustments or troubleshooting purposes. With its compact form factor, low power consumption, and compatibility with a wide range of microcontroller platforms, the ESP8266 module serves as a versatile and cost-effective solution for enabling IoT capabilities in solar tracking and battery monitoring systems. Its integration empowers these systems with enhanced connectivity, accessibility, and efficiency, paving the way for smarter and more sustainable energy management solutions.

The ESP8266 WiFi module typically refers to boards like the ESP-01, ESP-12, NodeMCU, and others, which use the ESP8266 microcontroller. These boards may have different pin configurations, but I'll provide a general overview based on the NodeMCU board, which is widely used.Here's a breakdown of the functions and common uses of each pin on a NodeMCU board, which has ESP8266 as its microcontroller:

1. Digital Pins (D0-D8)

- These pins can be used as digital input/output pins. They are typically used for interfacing with digital sensors, controlling LEDs, or any other digital device.
- D0 and D1 are also used for serial communication (UART) similar to Arduino's RX and TX pins.

2. Analog Pins (A0)

➢ The NodeMCU board typically has one analog input pin, labeled as A0. It can be used to read analog voltages from sensors.

3. Power and Ground Pins

➢ 3V3 and 5V: These pins provide regulated power supply at 3.3 volts and 5 volts, respectively.

➢ GND (Ground): These pins are connected to the ground of the system.

4. Special Pins

➢ RX and TX: These pins are used for serial communication. RX is the receiving pin, and TX is the transmitting pin.

➢ GPIO16 (D0): This pin has a special function as the wake-up pin from deep sleep mode.

➢ GPIO2 (D4): This pin should be held high during boot to enable the module to boot from the onboard flash memory.

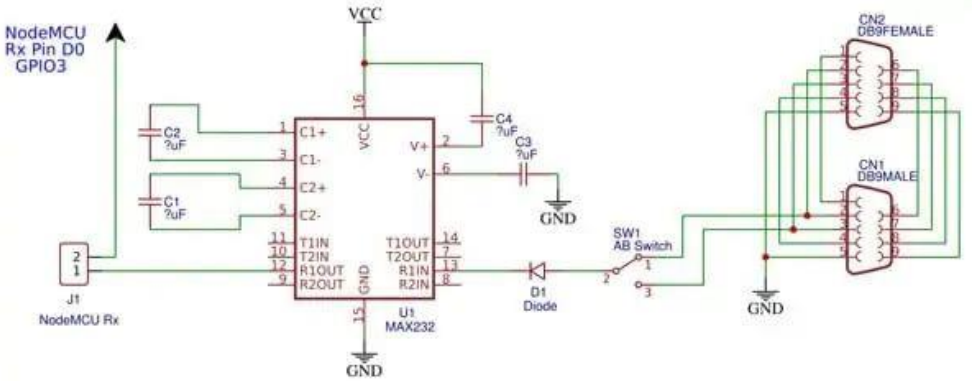
➢ EN (Enable): This pin is used to enable or disable the module.

➢ RST (Reset): This pin is used to reset the microcontroller.

5. Built-in LEDs:

➢ NodeMCU boards often come with built-in LEDs connected to specific pins for visual feedback. For example, there might be an LED connected to pin D0 (GPIO16).

4.6 Node MCU Microcontroller



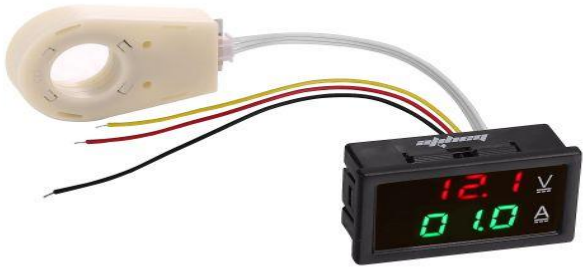
The NodeMCU microcontroller is a pivotal component within Solar Tracking and IoT Battery Monitoring systems with ESP8266, offering a versatile platform for integrating wireless communication and control capabilities. Built around the ESP8266 WiFi module, the NodeMCU combines the functionality of a microcontroller with built-in WiFi connectivity, making it an ideal choice for IoT applications. Its compact size, low cost, and ease of use make it well-suited for prototyping and developing IoT solutions. Integrated with sensors, actuators, and other peripherals, the NodeMCU facilitates data acquisition, processing, and transmission over WiFi networks. In Solar Tracking systems, the NodeMCU can receive inputs from sensors such as light-dependent resistors (LDRs) to dynamically adjust the orientation of solar panels for optimal energy capture. Similarly, in IoT Battery Monitoring systems, it

can monitor battery parameters such as voltage, current, and temperature, transmitting this data to cloud platforms for remote monitoring and analysis. The NodeMCU's compatibility with the Arduino IDE simplifies firmware development, allowing developers to leverage existing libraries and code examples to expedite project implementation. Additionally, its support for Lua scripting enables rapid prototyping and iteration of IoT applications. With its robust features, including GPIO pins, analog-to-digital converters (ADCs), and serial communication interfaces, the NodeMCU offers flexibility and scalability for a wide range of IoT projects. Overall, the NodeMCU microcontroller empowers Solar Tracking and IoT Battery Monitoring systems with ESP8266, enabling efficient, reliable, and connected energy management solutions.

4.7 Lithium-ion Battery

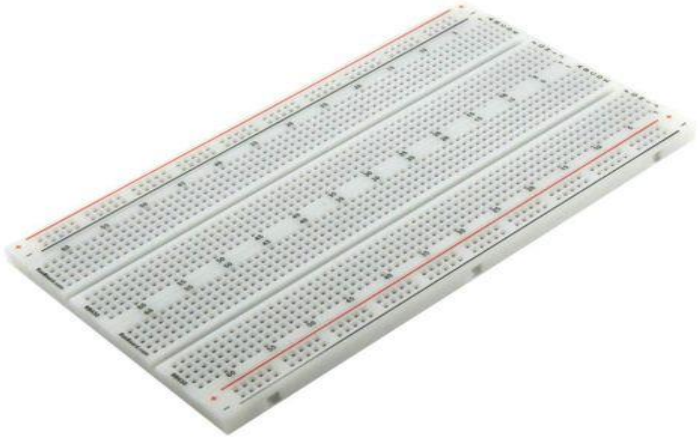
Lithium-ion batteries play a critical role in Solar Tracking and IoT Battery Monitoring systems with ESP8266, serving as the primary energy storage solution to ensure uninterrupted operation and reliable performance. Renowned for their high energy density, lightweight construction, and rechargeable capabilities, lithium-ion batteries are ideally suited for mobile and remote applications where space and weight considerations are paramount. Within these systems, lithium-ion batteries store the energy harvested from solar panels during periods of sunlight abundance, providing a stable power source for continuous operation, even during periods of low or no sunlight. This stored energy is essential for powering the various components of the system, including microcontrollers, sensors, and wireless communication modules like the ESP8266. Moreover, lithium-ion batteries offer fast charging capabilities and exhibit minimal self-discharge rates, ensuring efficient energy utilization and prolonged battery life. Additionally, their high cycle life and robust performance characteristics make them well-suited for long-term deployment in outdoor environments, where they must withstand temperature variations, humidity, and other environmental factors. Integrating lithium-ion batteries into Solar Tracking and IoT Battery Monitoring systems enhances their reliability, efficiency, and autonomy, enabling them to operate autonomously while providing users with real-time insights into energy usage and system performance. Overall, lithium-ion batteries are indispensable components in these systems, enabling the storage and utilization of solar energy to power IoT applications and ensure sustainable energy management.

4.8 Volt Meter & Amp Meter



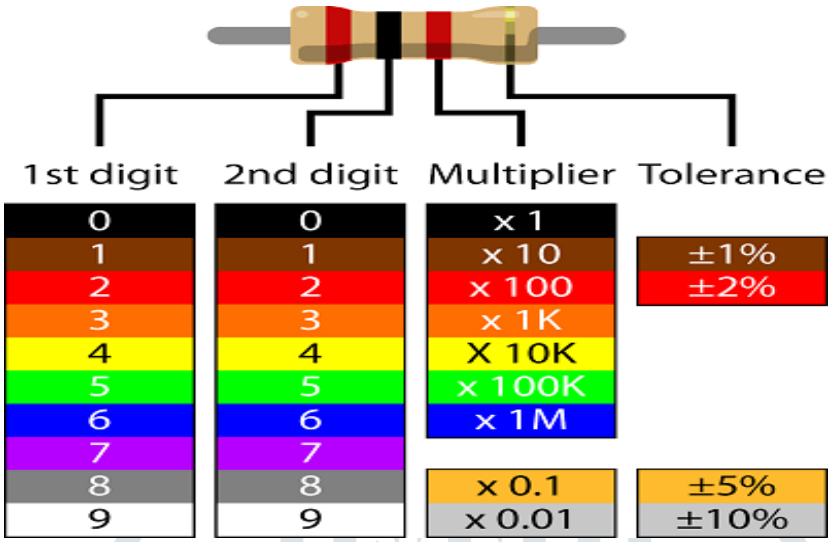
Voltmeters and ammeters are indispensable components within Solar Tracking and IoT Battery Monitoring systems with ESP8266, providing essential measurements of voltage and current to ensure efficient energy management and system operation. Voltmeters measure the electrical potential difference, or voltage, across various components within the system, including solar panels, batteries, and circuits. This information is crucial for monitoring the performance of these components and optimizing energy capture and utilization. By measuring voltage levels, volt meters help ensure that solar panels are generating the expected voltage output and that batteries are charging and discharging within safe voltage ranges. Ammeters, on the other hand, measure the flow of electrical current through the system, providing insights into power consumption, battery charging/discharging rates, and overall system efficiency. By monitoring current levels, ammeters enable users to assess energy usage patterns, detect anomalies or malfunctions, and optimize system configurations for maximum energy efficiency. Integrated with microcontrollers such as the Arduino Uno or NodeMCU, volt meters and ammeters facilitate real-time data acquisition and transmission, enabling remote monitoring and control of the system via WiFi connectivity. This allows users to access critical information about voltage, current, and power levels from anywhere, facilitating proactive maintenance and troubleshooting. With their compact size, accuracy, and compatibility with ESP8266 modules, volt meters and ammeters play a vital role in ensuring the reliability, efficiency, and performance of Solar Tracking and IoT Battery Monitoring systems.

4.9 Breadboard



Breadboards are fundamental components in the development and prototyping of electronic circuits, including Solar Tracking and IoT Battery Monitoring systems with ESP8266. These versatile tools provide a convenient platform for quickly and securely assembling electronic circuits without the need for soldering. Within such systems, breadboards serve as the foundation upon which various components, including microcontrollers, sensors, resistors, capacitors, and wires, are interconnected to create functional circuits. Their modular design consists of a grid of interconnected metal clips housed within an insulating base, allowing components to be easily inserted and connected by simply inserting their leads into the appropriate holes. This flexibility enables rapid experimentation and iteration during the design and testing phases, facilitating the exploration of different circuit configurations and component placements. Additionally, breadboards offer excellent visibility and accessibility, allowing developers to easily inspect and troubleshoot circuits by visually tracing connections and making adjustments as needed. Integrated with microcontrollers such as the Arduino Uno or NodeMCU, breadboards streamline the prototyping process, enabling developers to quickly implement and test new ideas and functionalities. Moreover, their reusable nature makes them cost-effective solutions for iterative design processes and educational purposes. Overall, breadboards play a crucial role in the development and refinement of Solar Tracking and IoT Battery Monitoring systems, providing a versatile and accessible platform for creating and testing electronic circuits.

4.10 Resistors 10k

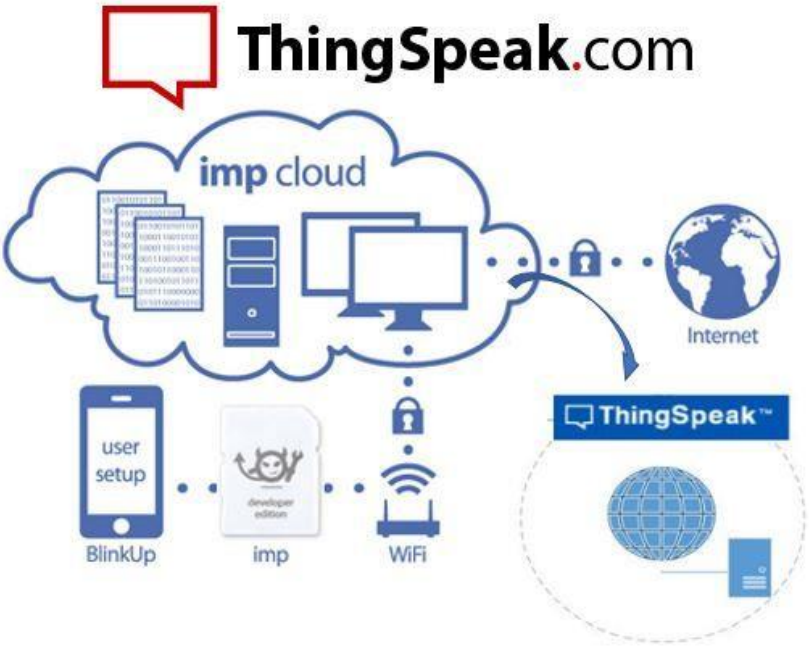


Within Solar Tracking and IoT Battery Monitoring systems with ESP8266, 10k ohm resistors serve as indispensable components, crucial for various aspects of circuit design and functionality. These resistors play a multifaceted role, aiding in voltage division, current limiting, signal stabilization, and biasing within electronic circuits. Their primary function often involves voltage division, where they are employed alongside other resistors to scale down voltages for sensor inputs or establish reference voltages. Additionally, 10k ohm resistors serve as pull-up or pull-down resistors in digital circuits, ensuring signal stability and preventing floating inputs. They also contribute to current limiting, safeguarding components from potential damage due to excessive current flow. Moreover, in certain sensor applications, 10k ohm resistors are utilized for biasing purposes, establishing the operating point of the sensor or setting reference voltages. Their compatibility with various sensors, microcontrollers, and other electronic components, coupled with their reliability and ease of integration, make them indispensable for achieving accurate sensor readings, ensuring signal integrity, and safeguarding circuit components. In essence, 10k ohm resistors are versatile and essential elements that play a vital role in enabling the efficient operation and functionality of Solar Tracking and IoT Battery Monitoring systems.

4.8 Battery level indicator

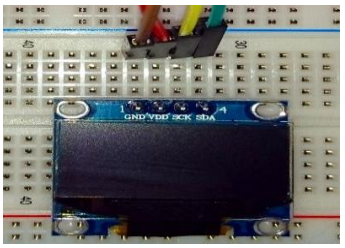
A battery level indicator is a crucial feature within Solar Tracking and IoT Battery Monitoring systems with ESP8266, providing real-time feedback on the charge level of the battery bank. This indicator typically comprises a visual display, such as LED indicators or a digital display, which conveys the current state of the battery's charge. The indicator offers valuable insights into the available energy reserves, allowing users to assess the system's power status at a glance.Incorporating a battery level indicator enables users to monitor the health and performance of the battery bank, ensuring that it remains adequately charged for continuous system operation. By displaying the battery's charge level in real-time, users can take proactive measures to recharge the battery when necessary, preventing unexpected power outages and downtime.Furthermore, the battery level indicator enhances system efficiency by optimizing energy management. Users can adjust energy consumption or implement energy-saving measures based on the battery's charge level, thereby prolonging battery life and maximizing overall system reliability.Integrated with microcontrollers like the Arduino Uno or NodeMCU, the battery level indicator receives data from battery monitoring sensors and translates it into a user-friendly display format. This allows users to access critical information about the battery's charge status remotely, facilitating proactive maintenance and troubleshooting.

4.12 Thinkspeek Platform



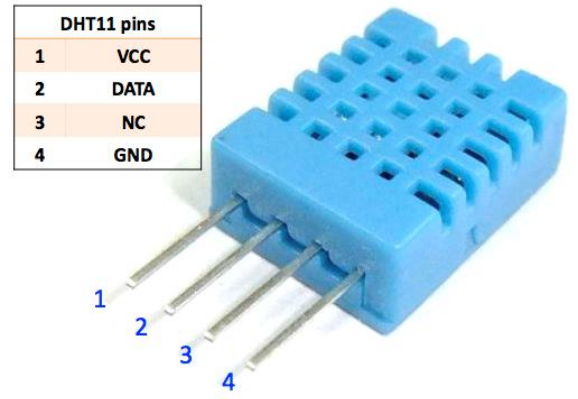
The ThingSpeak platform, developed by MathWorks, stands as a cornerstone in the realm of Internet of Things (IoT) applications, offering a comprehensive solution for collecting, analyzing, and visualizing data from a multitude of IoT devices and sensors. Specifically within Solar Tracking and IoT Battery Monitoring systems featuring ESP8266 modules, ThingSpeak plays a pivotal role in enabling remote monitoring and management of crucial system parameters. Through its intuitive interface, ThingSpeak facilitates the seamless integration of ESP8266 modules, allowing for the real-time streaming of data to cloud-based channels. Once collected, this data undergoes robust analysis using ThingSpeak's powerful analytics tools, including customizable MATLAB scripts and built-in functions, enabling users to gain valuable insights into system performance and energy utilization patterns. Moreover, ThingSpeak offers a diverse array of visualization options, ranging from line charts to heatmaps, empowering users to interpret data quickly and effectively. Beyond data analysis, ThingSpeak's RESTful API enables seamless integration with external services, facilitating automation and remote control based on predefined conditions. With its user-friendly interface, robust analytics capabilities, and seamless integration with ESP8266 modules, ThingSpeak serves as a versatile and indispensable platform for Solar Tracking and IoT Battery Monitoring systems, offering enhanced efficiency, reliability, and control.

4.13 OLED Display



The SSD1306 is a popular OLED (Organic Light Emitting Diode) display controller that is commonly used with microcontrollers like Arduino. It allows you to easily interface with OLED displays, which are known for their high contrast, low power consumption, and wide viewing angles. In the realm of renewable energy, solar power stands out as a promising source of clean and sustainable electricity. However, optimizing solar panel efficiency is crucial for maximizing energy generation. One effective method to enhance efficiency is through solar tracking systems, which adjust the orientation of solar panels to align with the sun's position throughout the day.In this project, we combine the power of Arduino microcontrollers with IoT technology to create a solar tracking system. The system utilizes an Arduino board, alongside sensors and actuators, to dynamically adjust the position of solar panels for optimal sunlight exposure. Additionally, we integrate an ESP8266 module for IoT-based battery monitoring, enabling users to remotely monitor the system's battery status.One of the key features of our project is the inclusion of an OLED display. This display provides real-time information such as temperature readings, DHT11 sensor values, battery voltage, and battery percentage. By presenting this data in a user-friendly format, users can easily monitor the system's performance and make informed decisions regarding maintenance or adjustments.In the following sections, we will delve into the details of our solar tracking system, including the hardware setup, software implementation, and integration of IoT-based battery monitoring. We will also discuss the benefits of utilizing OLED displays for real-time data visualization in renewable energy systems.

4.14 DHT11



The DHT11 sensor epitomizes a foundational cornerstone within the realm of environmental sensing, offering an affordable yet robust solution for measuring temperature and humidity levels with remarkable accuracy. Its intrinsic design incorporates a sophisticated digital sensor, meticulously calibrated to provide precise readings while maintaining an unparalleled level of simplicity in operation.At the heart of the DHT11's functionality lies its innate ability to seamlessly communicate digital data via a single-wire interface, rendering it exceptionally user-friendly and adaptable across a myriad of electronic projects. This inherent versatility has propelled the DHT11 into the spotlight, positioning it as a staple component in various domains ranging from meteorology and climate research to smart home automation and industrial monitoring systems.The allure of the DHT11 extends beyond its technical prowess, as it embodies a perfect synergy of reliability, affordability, and accessibility. Its compact form factor belies its capability, making it an ideal choice for applications where space constraints and power efficiency are paramount considerations. Furthermore, its compatibility with popular microcontroller platforms, such as Arduino

and ESP8266, further enhances its appeal, opening doors to a vast ecosystem of development tools and resources.In the hands of enthusiasts, hobbyists, and professionals alike, the DHT11 sensor serves as a conduit for capturing vital environmental data, enabling informed decision-making and facilitating the implementation of proactive measures to address changing conditions. Whether deployed in weather monitoring stations, indoor climate control systems, or agricultural automation setups, the DHT11 continues to exemplify the pinnacle of reliability and performance in temperature and humidity sensing technology.

CHAPTER 5: SOFTWARE IMPLEMEMTATION

Arduino 1.0.6 software tools used to program microcontroller. The working of software tool is explained below in detail.

Programming Microcontroller

A compiler for an abnormal state dialect decreases generation time. To program the Arduino UNO microcontroller the Arduino is utilized. The writing computer programs is done entirely in the installed C dialect. Arduino is a suite of executable, open source programming advancement devices for the microcontrollers facilitated on the Windows stage.

Arduino is a device for appearing well and good and control a greater amount of the physical world than your desktop PC. It's an open-source physical registering stage in view of a straightforward microcontroller board, and an improvement domain for composing programming for the board.

One of the challenges of programming microcontrollers is the restricted measure of assets the developer needs to manage. In PCs assets, for example, RAM and preparing speed are essentially boundless when contrasted with microcontrollers. Conversely, the code on microcontrollers ought to be as low on assets as could reasonably be expected

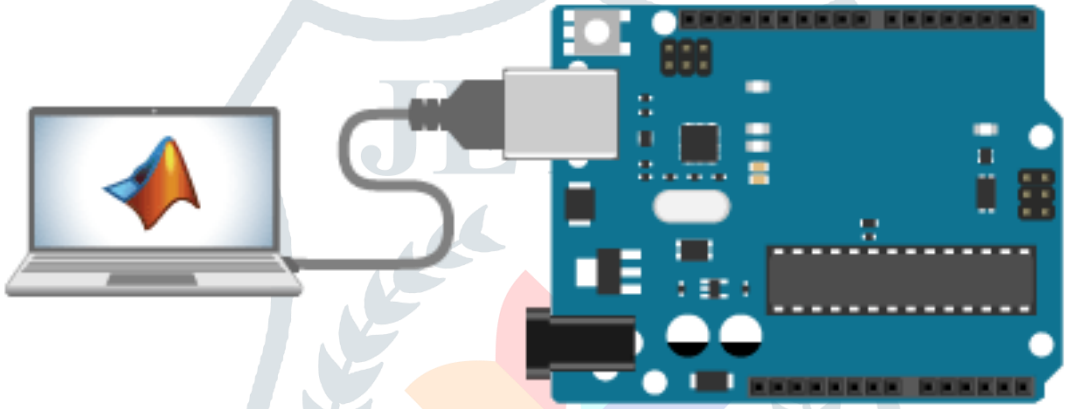
About Arduino Compiler

Get an Arduino board and USB cable

You additionally require a standard USB link (An attachment to B plug): the kind you would associate with a USB printer, for instance. (For the Arduino Nano, you'll require an A to Mini-B link.)

Connect the board

The Arduino Uno, Mega, Duemilanove and Arduino Nano consequently draw control from either the USB association with the PC or an outer power supply. In case you're utilizing an Arduino Diecimila, you'll have to ensure that the board is conFigureured to draw control from the USB association. The power source is chosen with a jumper, a little bit of plastic that fits onto two of the three sticks between the USB and power jacks. Watch that it's on the two sticks nearest to the USB port. Associate the Arduino board to your PC utilizing the USB link. The green power LED (named PWR) ought to go on.



Writing Sketches

Software written using Arduino are called sketches. These sketches are written in the text editor. Sketches are saved with the file extension .ino. It has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom right hand corner of the window displays the current board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

NB: Versions of the IDE prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

Check

Checks your code for mistakes.

Transfer

Assembles your code and transfers it to the Arduino I/O board. See transferring beneath for subtle elements.

Note: If you are utilizing an outer software engineer, you can hold down the "move" key on your PC when utilizing this symbol. The content will change to "Transfer utilizing Programmer"

New

Makes another draw.

	Open Presents a menu of all the representations in your sketchbook. Clicking one will open it inside the present window. Note: because of a bug in Java, this menu doesn't scroll; on the off chance that you have to open a portray late in the rundown, utilize the File | Sketchbook menu.
	Spare Recoveries your outline.
	Serial Monitor ,Opens the serial screen..

Table 5.1: Writing Sketches

Extra charges are found inside the five menus: File, Edit, Sketch, Tools, Help. The menus are setting delicate which implies just those things applicable to the work as of now being done are accessible.

Select your serial port

Select the serial gadget of the Arduino board from the Tools | Serial Port menu. This is probably going to be COM3 or higher (COM1and COM2 are typically saved for equipment serial ports). To discover, you can disengage your Arduino board and re-open the menu; the section that vanishes ought to be the Arduino board. Reconnect the board and select that serial port.

Upload the program

Before transferring your portray, you have to choose the right things from the Tools > Board and Tools > Serial Portmenus. The sheets are depicted beneath. On the Mac, the serial port is most likely something like/dev/tty.usbmodem241 On Windows, it's presumably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to discover, you search for USB serial gadget in the ports segment of the Windows Device Manager. On Linux, it ought to be/dev/ttyUSB0,/dev/ttyUSB1 or comparable.

Once you've chosen the right serial port and board, press the transfer catch in the toolbar or select the Upload thing from the File menu. Current Arduino sheets will reset naturally and start the transfer. With more established sheets (pre-Diecimila) that need auto-reset, you'll have to press the reset catch on the board just before beginning the transfer. On most sheets, you'll see the RX and TX LEDs flicker as the portray is transferred. The Arduino condition will show a message when the transfer is finished, or demonstrate a blunder. When you transfer a portray, you're utilizing the Arduino boot loader, a little program that has been stacked on to the microcontroller on your board. It enables you to transfer code without utilizing any extra equipment. The boot loader is dynamic for a couple of moments when the board resets; at that point it begins whichever outline was most as of late transferred to the microcontroller. The boot loader will squint the on-board (stick 13) LED when it begins (i.e. at the point when the board resets).

Presently, just tap the "Transfer" catch in the earth. Hold up a couple of moments - you should see the RX and TX leds on the board blazing. In the event that the transfer is fruitful, the message "Done transferring." will show up in the status bar. (Note: If you have an Arduino Mini, NG, or other board, you'll have to physically exhibit the reset

catch on the board promptly before squeezing the transfer catch.)

Figure 5.6: Compilation under Process

A couple of moments after the transfer completes, you should see the stick 13 (L) LED on the board begin to flicker (in orange). In the event that it does, congrats! You've gotten Arduino up-and-running.

To upload code to an Arduino Uno using the Arduino IDE, follow these steps:

1. **Install Arduino IDE**: If you haven't already, download and install the Arduino IDE from the official Arduino website (https://www.arduino.cc/en/software).

2. **Connect Arduino Uno**: Connect your Arduino Uno board to your computer using a USB cable.

3. **Open Arduino IDE**: Launch the Arduino IDE application.

4. **Select Board**: Go to the "Tools" menu, then "Board", and select "Arduino Uno" from the list of available boards.

5. **Select Port**: In the same "Tools" menu, navigate to "Port" and select the port to which your Arduino Uno is connected. The port number may vary depending on your operating system.

6. **Write or Open Code**: Write your code in the Arduino IDE's editor window, or open an existing sketch from the "File" menu.

7. **Verify/Compile Code**: Click the checkmark icon (or go to "Sketch" > "Verify/Compile") to compile your code. This step checks for any errors in your code.

8. **Upload Code**: Once your code compiles successfully, click the right-arrow icon (or go to "Sketch" > "Upload") to upload the code to your Arduino Uno.

9. **Wait for Upload**: The Arduino IDE will compile your code again and then start uploading it to the Arduino Uno. During this process, you'll see a message at the bottom of the IDE indicating the progress.

10. **Upload Complete**: Once the upload is complete, you should see a "Done uploading" message in the status bar. Your code is now running on the Arduino Uno.

That's it! You have successfully uploaded code to your Arduino Uno using the Arduino IDE. You can now disconnect the Arduino Uno from your computer and test your project.

Setting up Thingspeak

Setting up ThingSpeak for IoT-based data logging and visualization is a straightforward process. ThingSpeak is an IoT platform that allows you to collect, analyze, and visualize sensor data in real-time. Here's a step-by-step guide to setting up ThingSpeak:

1. **Create a ThingSpeak Account:**
   Go to the ThingSpeak website (thingspeak.com) and sign up for a free account. If you already have an account, simply log in.

2. **Create a Channel:**
   Once logged in, navigate to the Channels tab and click on "New Channel" to create a new channel. You will need to provide some basic information about your channel, such as a name, description, and field labels.

3. **Configure Channel Fields:**
   Specify the number of fields you need for your data. Each field represents a different type of data you want to collect. You can give each field a name and choose its data type (e.g., numeric, string, etc.).

4. **Set Up API Keys:**
   After creating your channel, go to the API Keys tab to generate API keys. You will need these keys to send data to your channel from your IoT device. ThingSpeak supports both read and write API keys, so you can control who can access your data.
5. **Connect Your Device:**
   Configure your IoT device to send data to ThingSpeak using the provided API keys. This typically involves writing code to send HTTP requests to ThingSpeak's API endpoints with your data payload.
6. **Send Data to ThingSpeak:**
   Once your device is configured, it will start sending data to your ThingSpeak channel. You can view the incoming data in real-time on your ThingSpeak channel page.

7. **Set Up Visualization:**

ThingSpeak offers various visualization options, including charts, gauges, and maps, to help you analyze your data. You can customize your channel's visualization settings to display your data in the most meaningful way.

8. **Explore Additional Features:**

ThingSpeak offers additional features such as MATLAB analysis, triggers, and MATLAB visualizations for advanced data processing and analysis. Explore these features to take full advantage of the platform.

To program an ESP8266 using the Arduino IDE, follow these steps:

1**. Install the ESP8266 Board Package:**

- Open the Arduino IDE.
- Go to File > Preferences.
- In the Additional Board Manager URLs field, add the following URL: `http://arduino.esp8266.com/stable/package_esp8266com_index.json`
- Click OK to close the Preferences window.
- Go to Tools > Board > Boards Manager.
- Search for "esp8266" and install the "esp8266" package by ESP8266 Community.
- Close the Boards Manager.

2. **Select the ESP8266 Board:**

- Go to Tools > Board and select the appropriate ESP8266 board that you are using. For example, NodeMCU 1.0 (ESP-12E Module).

3. **Set up the COM Port:**

- Go to Tools > Port and select the COM port to which your ESP8266 is connected.

4. **Write Your Code:**

- Write your Arduino sketch in the IDE.

5. **Upload Your Code:**

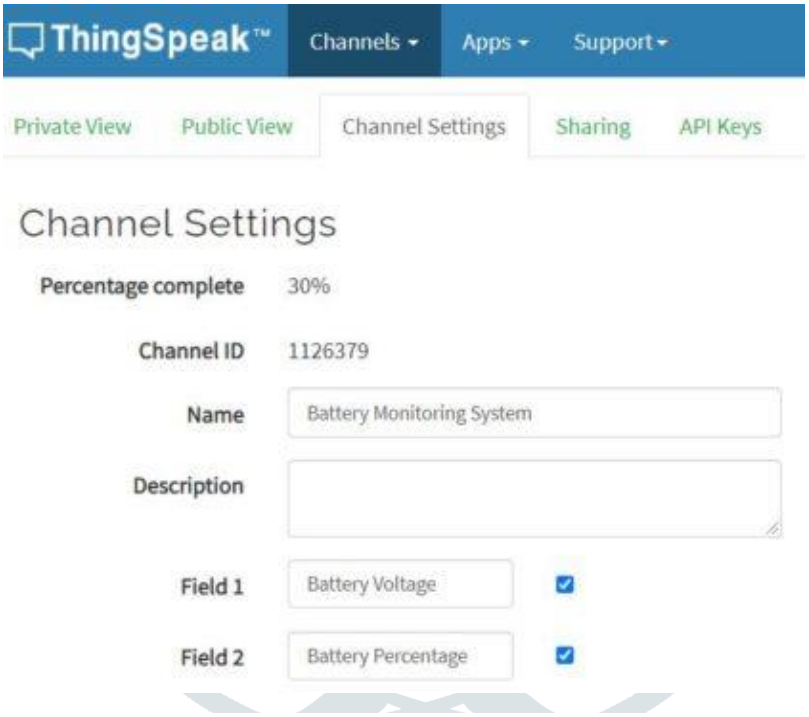
- Connect your ESP8266 board to your computer via USB.
- Click the Upload button (right arrow icon) in the Arduino IDE to compile and upload your sketch to the ESP8266.
- Wait for the IDE to compile and upload the sketch to the board. The status messages in the bottom console will indicate if the upload was successful.

6. **Monitor Serial Output (Optional):**

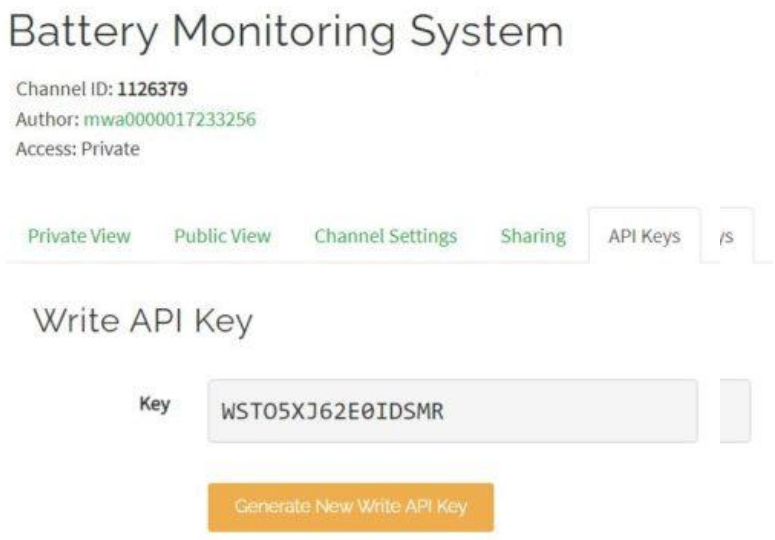
- If your sketch includes Serial.print() statements for debugging, you can monitor the serial output of the ESP8266 by opening the Serial Monitor in the Arduino IDE (Tools > Serial Monitor).

That's it! Your code should now be running on the ESP8266 board. You can disconnect the board from your computer and power it with an external power source if needed. Remember to select the correct board and COM port each time you upload a sketch to the ESP8266.

By following these steps, you can set up ThingSpeak to collect, analyze, and visualize sensor data from your IoT devices in real-time.



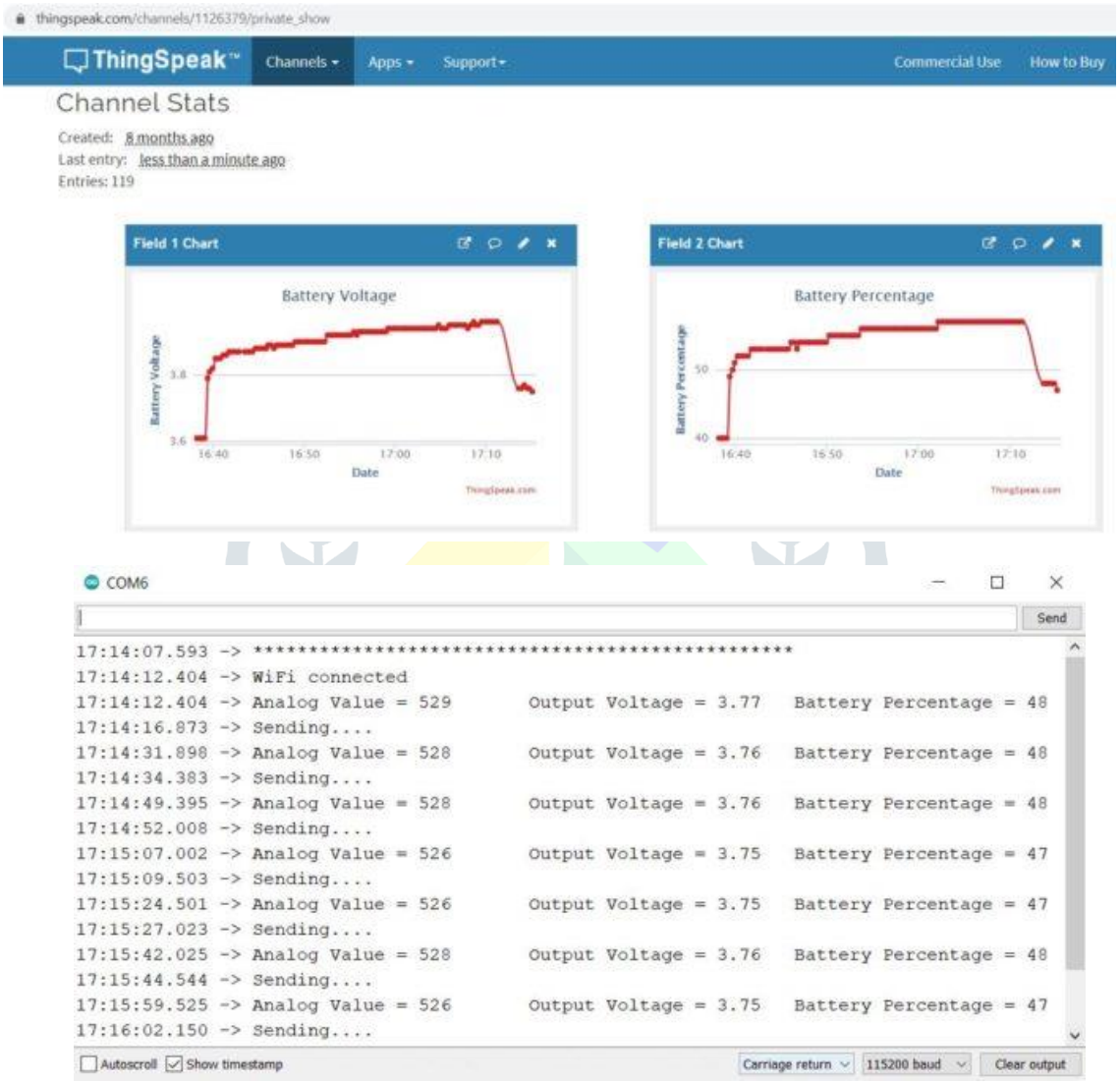
Then go to the API section of the dashboard and copy the **API Key**. This API key is needed in the code part.



IoT Based Battery Monitoring System using ESP8266 on Thingspeak

Open the **Serial Monitor** after uploading the code. The ESP8266 will try connecting to the WiFi Network. Once it connects to the WiFi Network, it will display the **Analog Value** along with **Battery Voltage** & **Percentage**.

Then go to the **private view** of Thingspeak Dashboard. The Battery Voltage and Battery Percentage will fill the graph. The graph will rise up when the device is charging and will go down when it's discharging.



CHAPTER 6: ADVANTAGES AND APPLICATIONS

6.1 Advantages

1. Enhanced energy capture efficiency through solar tracking.
2. Real-time monitoring of battery health parameters.
3. Remote accessibility for monitoring and control.
4. Insights and analysis capabilities for energy data.
5. Contribution to sustainable energy management practices.
6. Increased reliability and uptime of solar power systems.
7. Optimal utilization of available sunlight throughout the day.
8. Proactive maintenance through early detection of battery issues.
9. Reduction of electricity costs and reliance on grid power.
10. Integration with smart home or building automation systems for seamless operation.

6.2 Applications

1. Residential solar power systems.
2. Commercial and industrial installations.
3. Agricultural and rural applications.
4. Off-grid and remote locations.
5. Research and educational institutions.
6. Microgrid systems for community or neighborhood energy distribution.
7. Mobile and portable solar-powered devices for outdoor activities.
8. Emergency response and disaster recovery operations.
9. Electric vehicle charging stations powered by solar energy.
10. Sustainable development projects in remote or underserved areas.

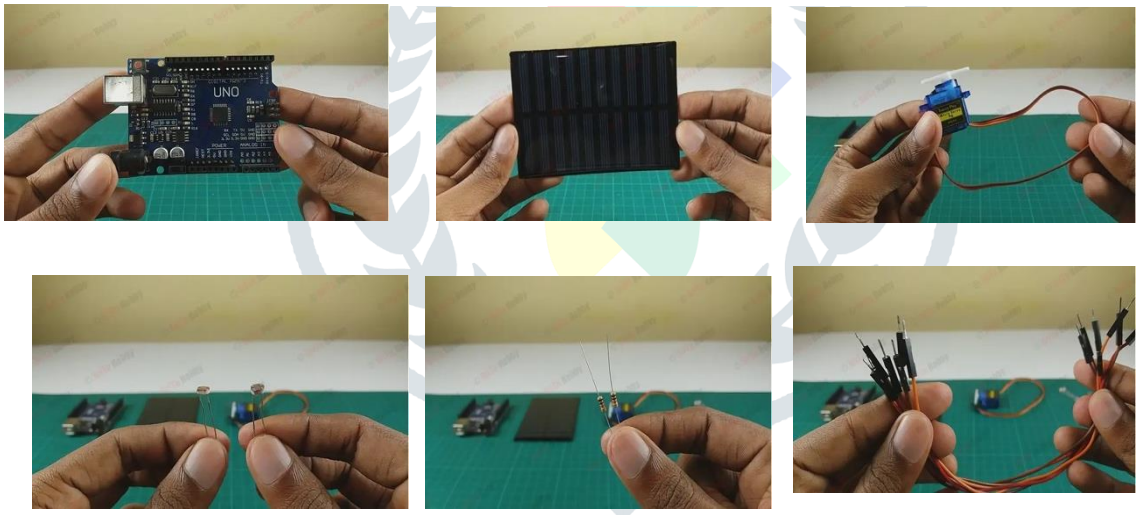
CHAPTER 7: EXPERIMENTAL RESULT

The required components are given below.

- Arduino UNO board x 1
- Solar panel x 1
- SG90 servo motor x 1
- LDR sensor x 2
- 10k resistor x 2
- Jumper wires x
- Rigifoam / Foam board / Cardboard

Step 1

Firstly, identify these components.



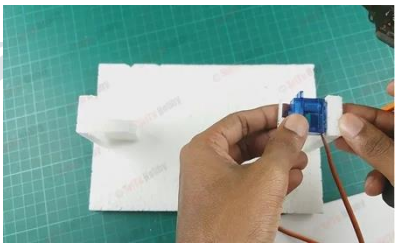
Step 2: Secondly, cut the base part of the project. To do this, use the following sizes.

Step 3

Thirdly, attach the following pieces to the base part.


Step 4

Then, attach the servo motor. For that, use the pictures below.

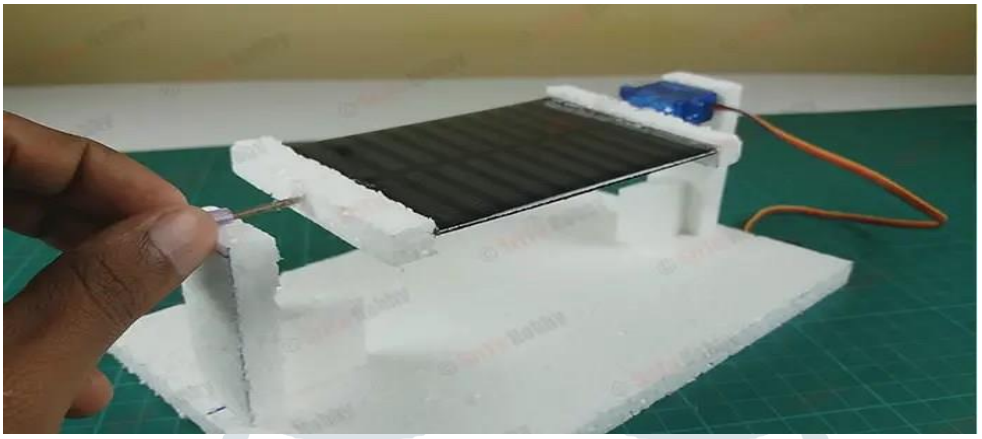
Step 5

Next, attach two pieces of rigifoam to the solar panel. After, attach an iron stick to one side of the solar panel.



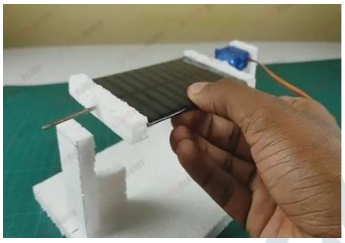
Step 6

Now, connect one side of it to the servo motor and the other side to the rigifoam piece.



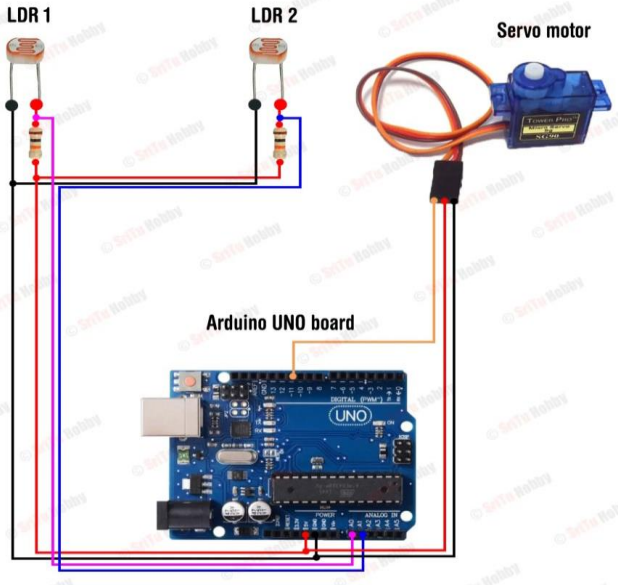
Step 7

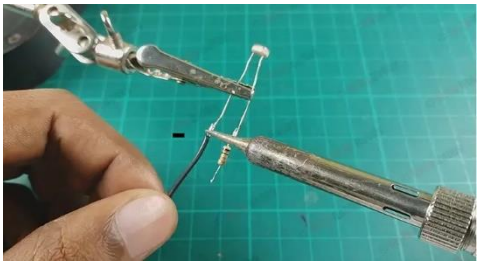
Then, solder the 10k resistor to one leg of the LDR. Also, solder this way for both sensors.

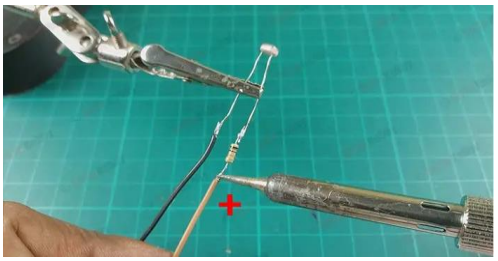


Step 8

Next, solder these sensors together. For that, use the circuit diagram below

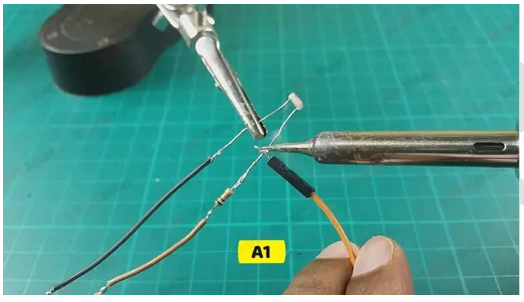


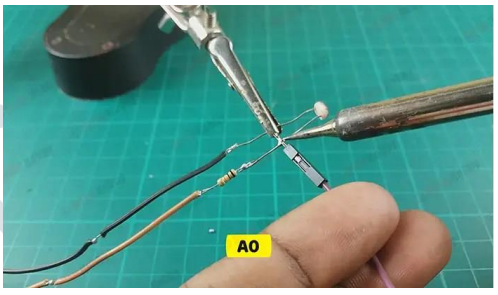




Step 9

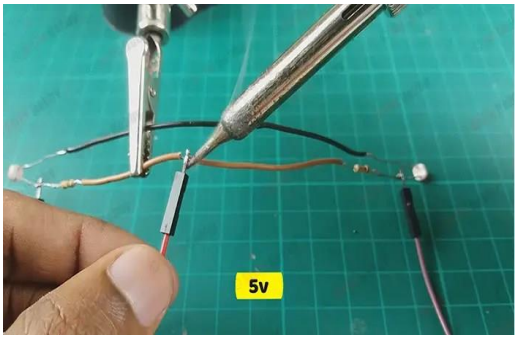
Afterward, solder the two jumper wires to the voltage divider points of these sensors. Please look at the circuit diagram above.

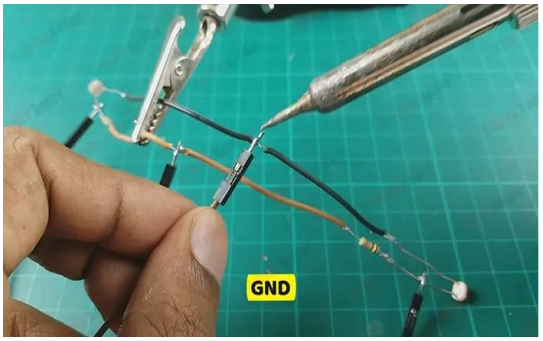




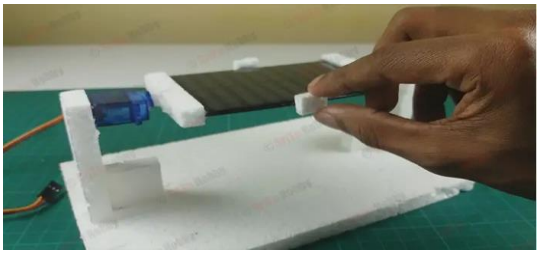
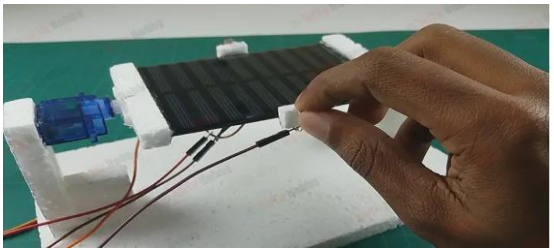
Step 10

Now, solder the 5v and GND jumper wires.



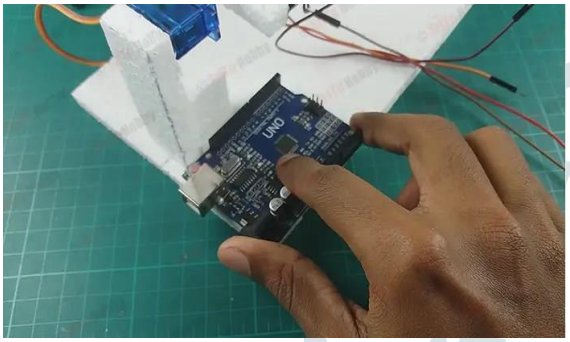
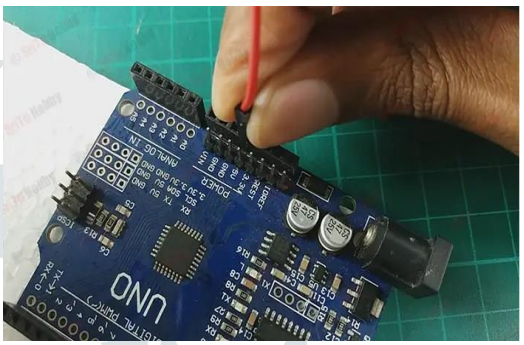


Step 11: Then, connect these sensors to both sides of the solar panel.

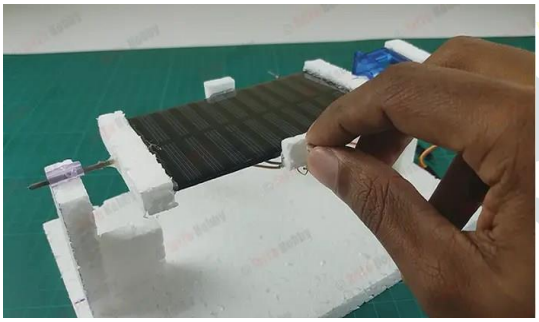
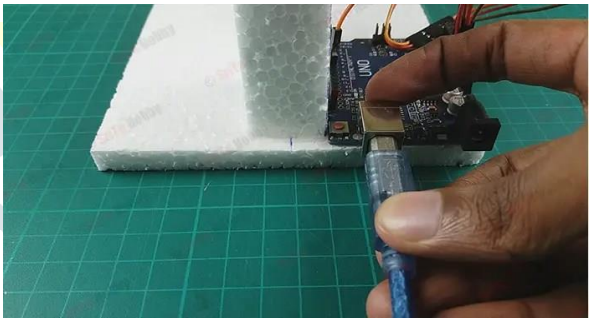
Step 12:

Next, mount the Arduino board and connect the LDR sensors and servo motor to it. You can use the circuit diagram above for that.

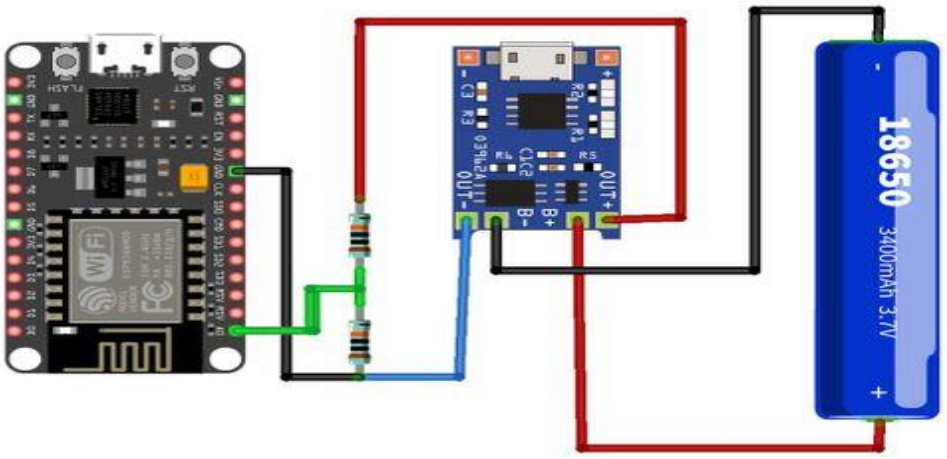



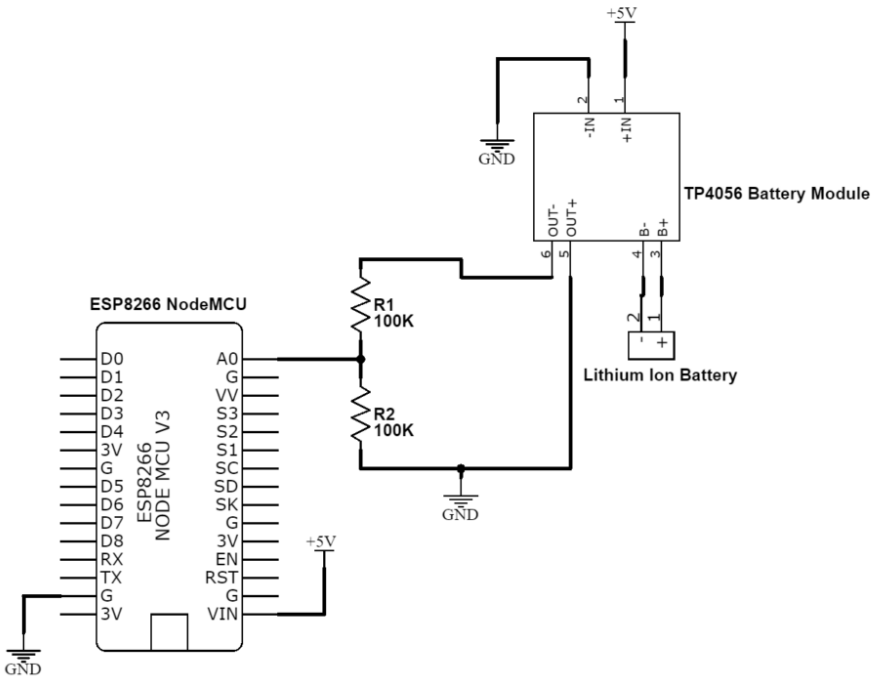
Step 13

Now, connect this project to your computer and upload the following program. It is as follows.

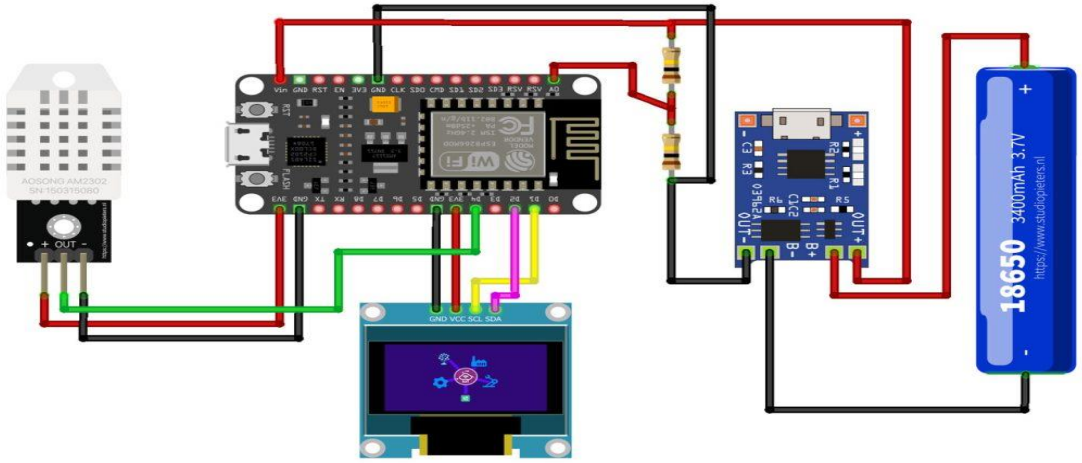



IoT Based Battery Status Monitoring System using ESP8266:





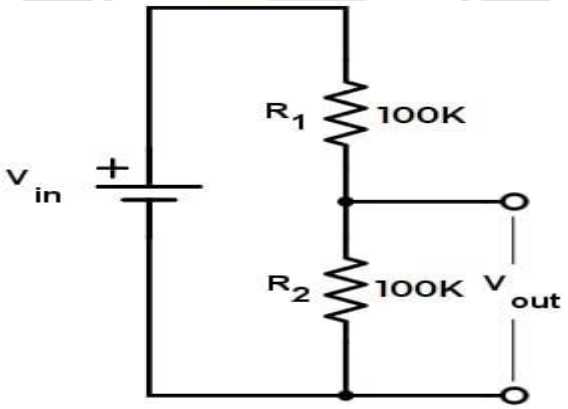
CIRCUITDIAGRAMS.IN **ELECTRO GADGET**



Voltage Divider Calculations

The maximum battery voltage is 4.2V and the cut-off voltage is 2.8V. Any values lesser than 3.3V will be easily supported by the ESP8266 analog pin (A0).

We have to first step down the upper voltage level for taking the analog value. The maximum battery voltage is 4.2V and there is a pair of 100KΩ resistors in series with the battery. This will give an output of 2.1V. Similarly, the minimum voltage is 2.8V as a cut-off voltage which steps down to 1.4V using the same voltage divider network. Now, both the upper and lower voltage is supported by the ESP8266 Analog pin.

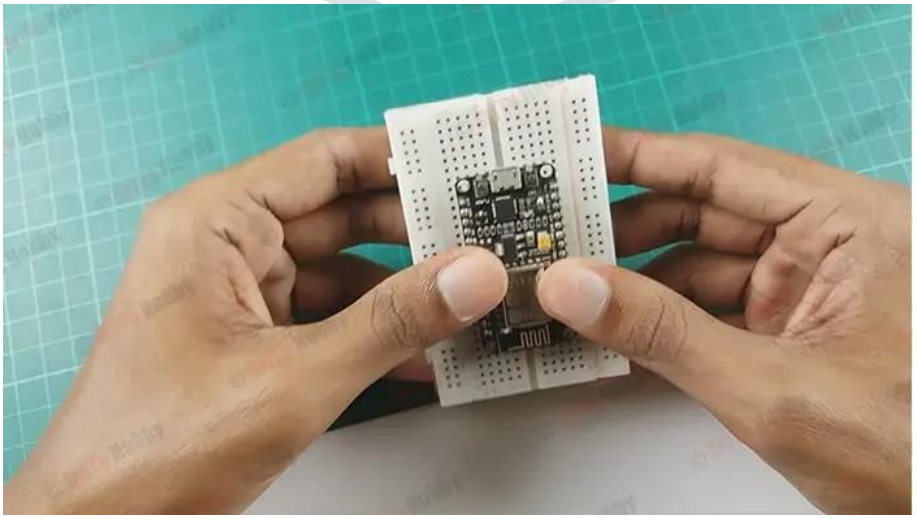


Formula:

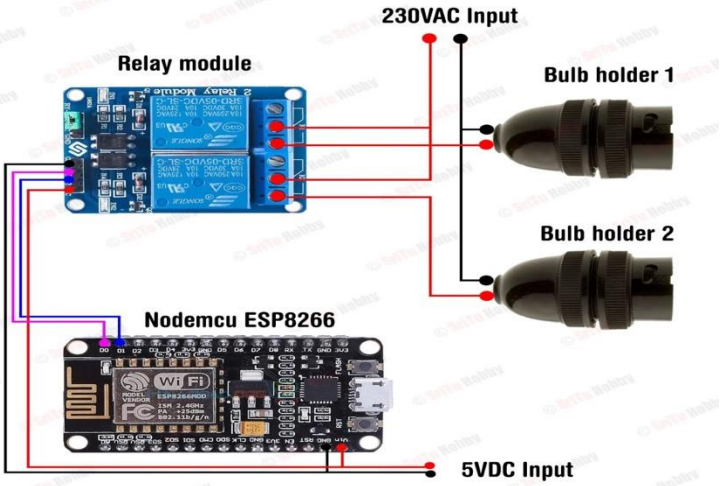
$$V_{out}=V_{in}\times[R_2 / (R_1+R_2)]$$

Step 1: Firstly, identify these components.

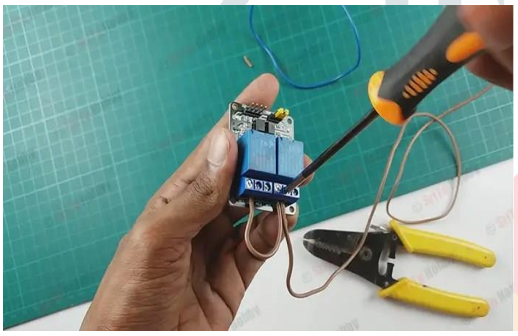
Step 2:Secondly, connect the Nodemcu board to the breadboard.

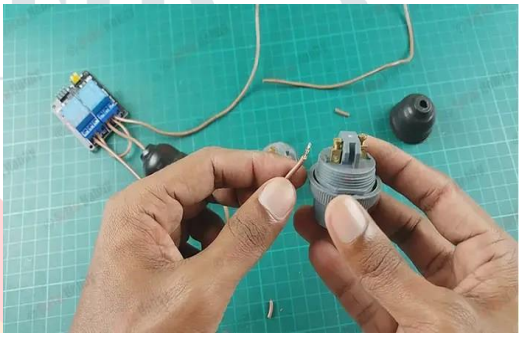


Step 3: Thirdly, connect the bulb holders to the relay module. For that, use the circuit diagram below.



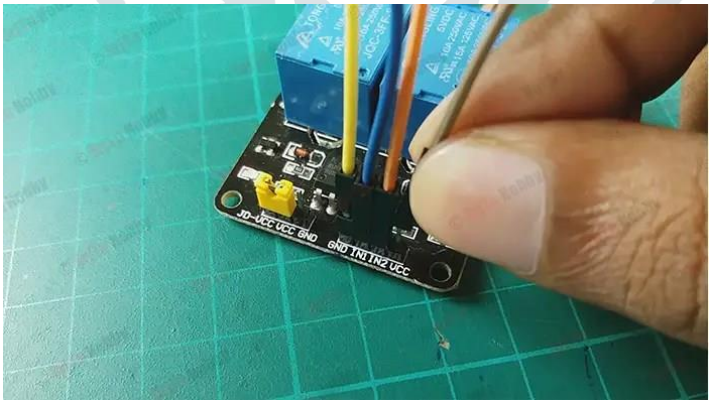
Step 4: Next, connect the plug top to the 230VAC input point.

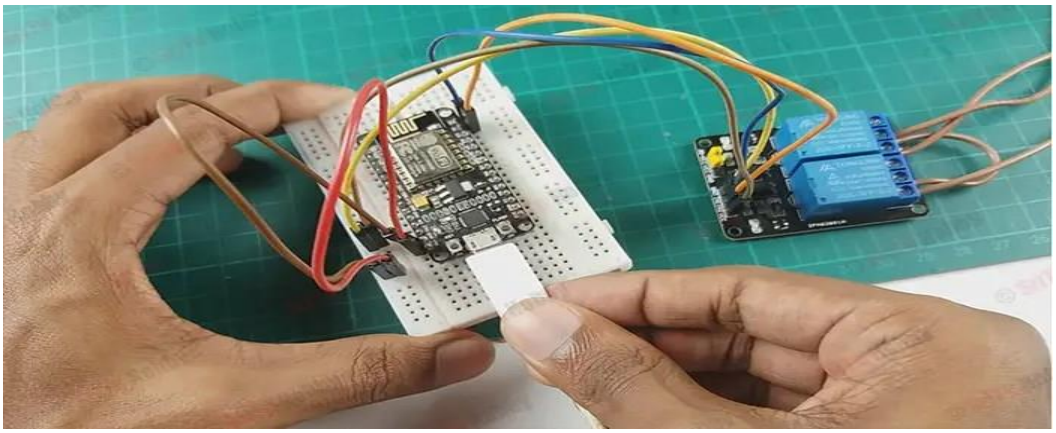


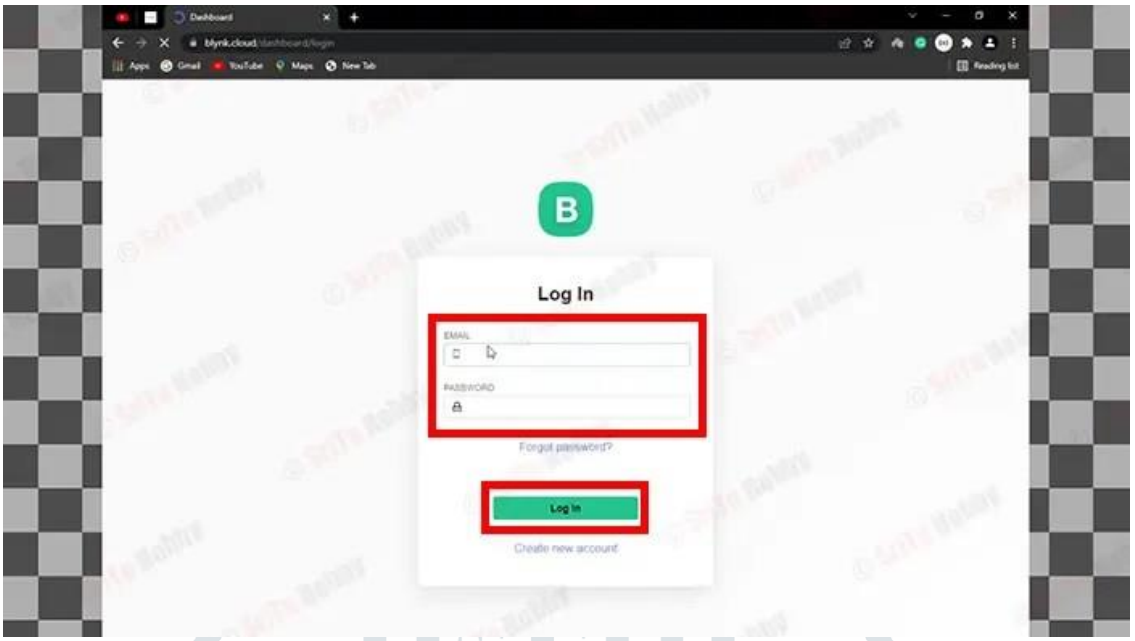


Step 5

OK, now connect the relay module to the Nodemcu board using the jumper wires. For that, use the circuit diagram above. Next, connect it to the computer.







Step 6

Now, let's set up the Blynk web application step by step. For that, follow the instructions below.

- First, go to the Blynk official website using your browser. Then login to this site using your email and password. (If you don't have a Blynk account, you must make a new account. For that, use this link. It will guide you)
- Next, click the template button and create a new template . For that, name it as you like. Also, select the hardware as ESP8266 and the connection as WIFI
- Then, click the "Datastreams" tab and create two Datastreams as VitualPin. Also, set the first pin and the second pin to V0 and V1. Then, select the data type as an integer.

- Now, click on the Web Dashboard tab. Then, drag and drop two buttons to the dashboard. Next, click the setting icon in the button and select the datastream we created earlier. That is, V0 for button one and V1 for button two. Finally click the save button.

- Next, click the Search Icon button. After, click the New Devices button and after click the "From template" button. Finally, select the template we created earlier.

OK, the Blynk web application is ready for us.

Step 7:OK, now let's create the program for this project. It's as follows.

- Full details of this project – Download
- Blynk library — Download
- WIFI library — Download
-

```
/*New Blynk app with Smart Automation
  Home Page
*/

//Include the library files
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
```

```
//Define the relay pins
#define relay1 D0
#define relay2 D1

#define BLYNK_AUTH_TOKEN "" //Enter your blynk auth token

char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "";//Enter your WIFI name
char pass[] = "";//Enter your WIFI password

//Get the button values
BLYNK_WRITE(V0) {
  bool value1 = param.asInt();
  // Check these values and turn the relay1 ON and OFF
  if (value1 == 1) {
    digitalWrite(relay1, LOW);
  } else {
    digitalWrite(relay1, HIGH);
  }
}

//Get the button values
BLYNK_WRITE(V1) {
  bool value2 = param.asInt();
  // Check these values and turn the relay2 ON and OFF
  if (value2 == 1) {
    digitalWrite(relay2, LOW);
  } else {
    digitalWrite(relay2, HIGH);
  }
}

void setup() {
  //Set the relay pins as output pins
  pinMode(relay1, OUTPUT);
  pinMode(relay2, OUTPUT);

  // Turn OFF the relay
  digitalWrite(relay1, HIGH);
  digitalWrite(relay2, HIGH);

  //Initialize the Blynk library
  Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}

void loop() {
  //Run the Blynk library
  Blynk.run();
}
```

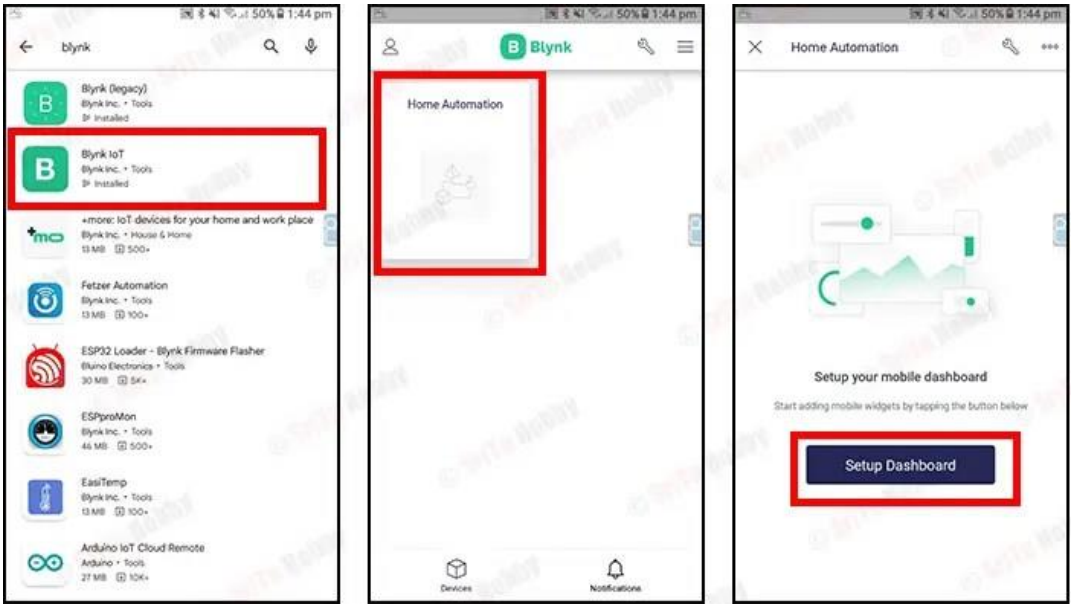
- Now, copy and paste the Blynk auth token. To do this, check the “Device Info” tab of your Blynk web application.
- Next, enter your correct WIFI name and password.

- Now, select the board and port. Then, upload this program to the Nodemcu board. (If you haven’t yet installed the ESP8266 boards, please use this link and follow the instructions)

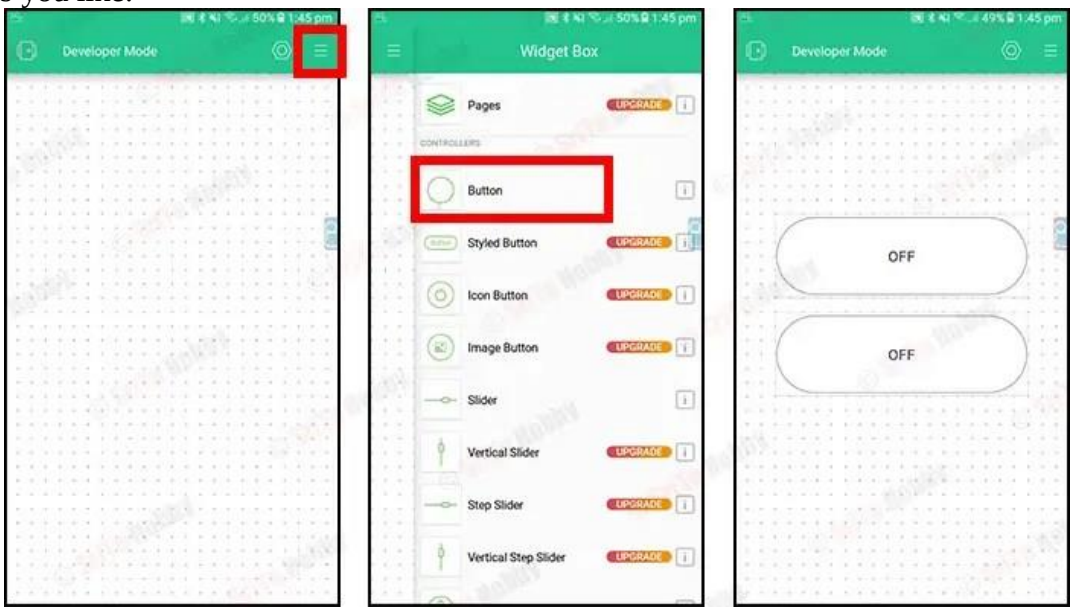
Step 8

OK, now let's set up the Blynk mobile dashboard. For that, follow the instructions below.

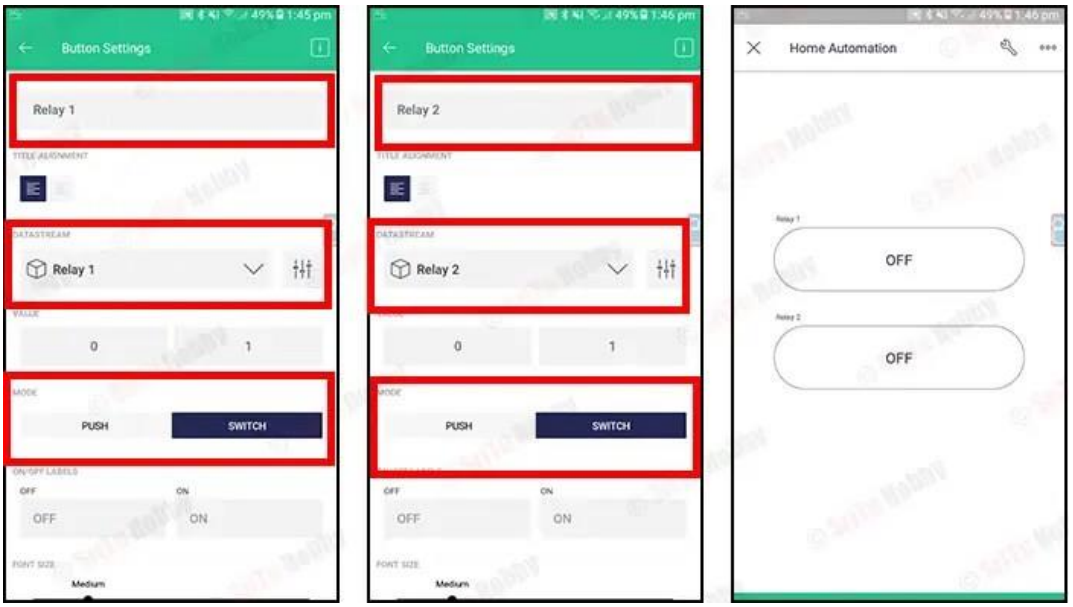
- First, download and install the Blynk app on your phone. Then, run this application. Now, you can see the template we created ealiar. Next, click this template and set up your dashboard.



- Now, click the upper right corner button and include the two buttons to the dashboard. Then, arrange these widgets as you like.



- Next, click the buttons one by one and select the detastreams V0 and V1 respectively. Also, select the mode as switch.



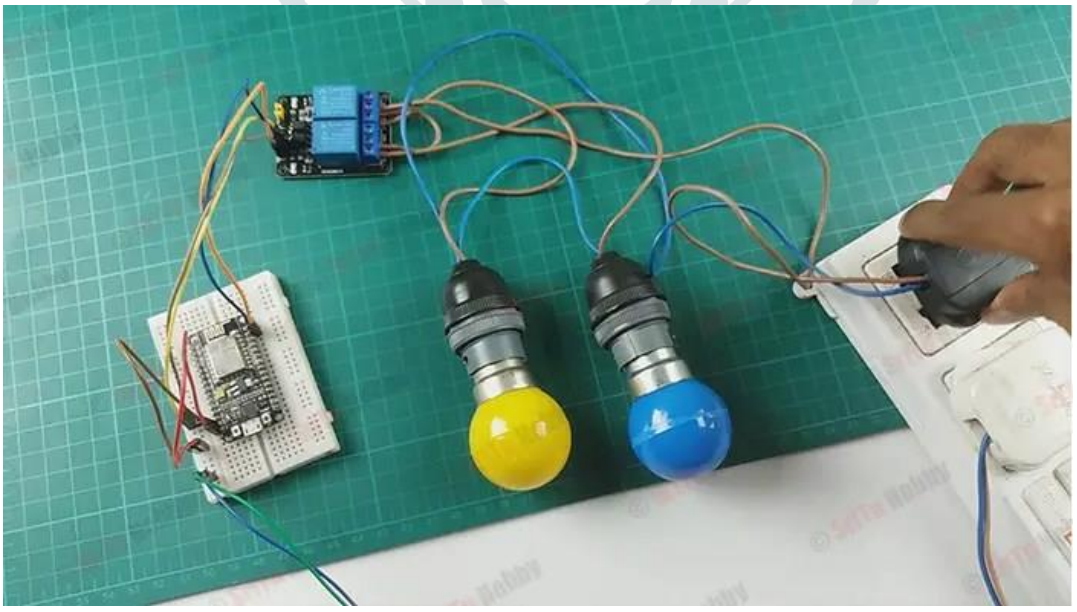
OK, the Blynk app is ready.

Step 9

Now, connect the 5 VDC external power supply to the Nodemcu board. For that, use the circuit diagram above.

Step 10

Finally, put the bulbs to the holders and connect the plug top to the AC voltage. **(If you have no knowledge of this AC voltage, please seek the assistance of an adult)**



OK, now you can operate these relays using the web or mobile dashboard. The full video guide is below. So, see you in the next project.

CHAPTER 8: CODE EXPLAINATION

SOLAR TRACKING SYSTEM WITH ARDUNIO:

MAIN CODE:

```
//Solar tracking system with ardunio

//Include the servo motor library#include <Servo.h>
//Define the LDR sensor pins#define LDR1 A0
#define LDR2 A1
//Define the error value. You can change it as you like#define error 10
//Starting point of the servo motorint Spoint = 90;
//Create an object for the servo motorServo servo;

void setup() {
//Include servo motor PWM pinservo.attach(11);
//Set the starting point of the servoservo.write(Spoint);
delay(1000);
}

void loop() {
//Get the  LDR  sensor  value int ldr1 = analogRead(LDR1);
//Get the  LDR  sensor  value int ldr2 = analogRead(LDR2);

//Get the difference of these valuesint value1 = abs(ldr1 - ldr2);
int value2 = abs(ldr2 - ldr1);

//Check these values using a IF condition
if ((value1 <= error) || (value2 <= error)) {

} else {
if (ldr1 > ldr2) { Spoint = --Spoint;
}
if (ldr1 < ldr2) { Spoint = ++Spoint;
}
}
//Write values on the servo motorservo.write(Spoint);
delay(80);
}
```

CODE EXPLAINATION:

```
// Include the servo motor library
#include <Servo.h>

// Define the LDR sensor pins
#define LDR1 A0#define LDR2 A1

// Define the error value. You can change it as you like
#define error 10

// Starting point of the servo motor
int Spoint = 90;

// Create an object for the servo motor
Servo servo;

void setup() {
// Include servo motor PWM pin
servo.attach(11);

// Set the starting point of the servo
servo.write(Spoint);

// Delay for stabilization
delay(1000);
}

void loop() {
// Get the LDR sensor value
int ldr1 = analogRead(LDR1);

// Get the LDR sensor value
int ldr2 = analogRead(LDR2);

// Get the difference of these values
```

```
int value1 = abs(ldr1 - ldr2);int value2 = abs(ldr2 - ldr1);

// Check these values using an IF condition
if ((value1 <= error) || (value2 <= error)) {
// If difference is within the error margin, do nothing
}
else {
// If difference is beyond the error margin
if (ldr1 > ldr2) {
// If ldr1 value is greater, decrement servo position
Spoint = --Spoint;

}
if (ldr1 < ldr2) {
// If ldr2 value is greater, increment servo position
Spoint = ++Spoint;
}
}

// Write the new position to the servo motor
servo.write(Spoint);

// Delay to allow servo to move
delay(80);
}
```

Explanation:

- The code starts with including the Servo library, which is required to control the servomotor.
- LDR1 and LDR2 are defined as analog pins A0 and A1 respectively, which areconnected to light-dependent resistors (LDRs).
- "error" is defined as 10, which sets the acceptable error margin for the difference inLDR readings.
- "Spoint" is initialized to 90, which represents the starting position of the servo motor.
- An object "servo" of the Servo class is created.
- In the setup () function:
- The servo motor is attached to pin 11.

- The starting position of the servo motor is set using servo.write().
- There's a delay of 1000 milliseconds for stabilization.
- In the loop () function:
- Analog readings from LDR1 and LDR2 are obtained.
- The absolute difference between the readings is calculated and stored in "value1" and"value2".
- If the difference is within the acceptable error margin, no action is taken.
- If the difference exceeds the error margin, the code checks which LDR has a highervalue and adjusts the servo position accordingly.
- The servo position is updated using servo.write().
- There's a delay of 80 milliseconds to allow the servo to move to the new position.

Used Library

- Servo Library Inclusion: The code begins by including the Servo library. This library providesfunctions to control servo motors.

- Defining LDR Pins: The pins connected to the Light Dependent Resistors (LDRs) are defined.
- `LDR1` is connected to pin A0, and `LDR2` is connected to pin A1.

- Error Margin Definition: The acceptable error margin for the difference in LDR readings isdefined as `error`. This value is set to 10, but it can be adjusted according to the requirements.

- Servo Motor Initialization: The variable `Spoint` is initialized to 90, representing the startingposition of the servo motor.

- Servo Object Creation: An object `servo` of the `Servo` class is created.

Setup Function:

- servo.attach(11): attaches the servo motor to pin 11.
- servo.write(Spoint): sets the starting position of the servo motor to “Spoint”.
- delay (1000): introduces a delay of 1000 milliseconds for stabilization.

Loop Function:

- Read the analog values from `LDR1` and `LDR2`.
- Calculate the absolute difference between the readings and store them in `value1` and `value2`.
- If the difference between the LDR readings is within the defined error margin, no action istaken.

- If the difference exceeds the error margin:
- Compare the LDR readings:
- If `ldr1` is greater than `ldr2`, decrement the servo position.
- If `ldr1` is less than `ldr2`, increment the servo position.
- Write the new position to the servo motor using `servo.write(Spoint)`.
- Introduce a delay of 80 milliseconds to allow the servo to move to the new position.

This code essentially implements a solar tracking system using Arduino and a servo motor, where the servo motor adjusts its position based on the readings from two LDRs to maximize exposure to sunlight.

IoT Based Battery Status Monitoring System using ESP8266

```
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <DHT.h>
#include <ESP8266WiFi.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_RESET    -1
#define DHTPIN D4     // Digital pin connected to the DHT sensor
#define DHTTYPE DHT11 // DHT 11

const char* ssid = "12345678";      // Enter your WiFi Network's SSID
const char* password = "12345678"; // Enter your WiFi Network's Password
const char* server = "api.thingspeak.com";
String apiKey = "VKH4CYC7UQ8D5EU0"; // Enter your ThingSpeak API Key

DHT dht(DHTPIN, DHTTYPE);

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

int analogInPin  = A0;    // Analog input pin
int sensorValue;          // Analog Output of Sensor
float calibration = 0.36; // Check Battery voltage using multimeter & add/subtract the value
int bat_percentage;

WiFiClient client;

void setup() {
  Serial.begin(115200);

  // Connect to WiFi
  WiFi.begin(ssid, password);
  Serial.print("Connecting to WiFi");
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("WiFi connected");
```

```
  // Initialize OLED display
  if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println(F("SSD1306 allocation failed"));
    for(;;);
  }

  // Display "EEE DEPARTMENT MAIN PROJECT" on OLED display for 2 seconds
  display.clearDisplay();
  display.setTextSize(1); // Increase text size
  display.setTextColor(SSD1306_WHITE);
  display.setCursor(0, 0); // Adjust cursor position
  display.print(F("EEE DEPARTMENT"));
  display.setTextSize(1); // Increase text size
  display.setCursor(0, 25); // Adjust cursor position
  display.print(F("MAIN PROJECT"));
  display.display();
  delay(5000); // Display for 2 seconds

  // Add additional text for 2 seconds
  display.clearDisplay();
  display.setTextSize(1); // Increase text size
  display.setTextColor(SSD1306_WHITE);
  display.setCursor(0, 0); // Adjust cursor position
  display.print(F("PRESENTED BY "));
  display.setTextSize(1); // Increase text size
  display.setCursor(0, 10); // Adjust cursor position
  display.print(F("(Batch No.: 03) "));
  display.setTextSize(1); // Increase text size
  display.setCursor(0, 25); // Adjust cursor position
  display.print(F("Under the Guidance of"));
  display.setTextSize(1); // Increase text size
  display.setCursor(0, 40); // Adjust cursor position
  display.print(F("Dr. M.C.V. Suresh"));
  display.display();
  delay(5000); // Display for 2 seconds

  // Initialize DHT sensor
  dht.begin();
}

void loop() {
  // Read temperature and humidity from DHT sensor
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();

  // Read battery voltage
  sensorValue = analogRead(analogInPin);
  float voltage = (((sensorValue * 3.3) / 1024) * 2 + calibration); //multiply by two as voltage divider network is
100K & 100K Resistor

  bat_percentage = mapfloat(voltage, 2.8, 4.2, 0, 100); //2.8V as Battery Cut off Voltage & 4.2V as Maximum
Voltage

  if (bat_percentage >= 100) {
    bat_percentage = 100;
  }
```

```
if (bat_percentage <= 0) {
  bat_percentage = 1;
}

// Print temperature, humidity, battery voltage, and battery percentage to Serial Monitor
Serial.print("Temperature: ");
Serial.print(temperature);
Serial.println(" °C");
Serial.print("Humidity: ");
Serial.print(humidity);
Serial.println(" %");
Serial.print("Battery Voltage: ");
Serial.print(voltage);
Serial.println(" V");
Serial.print("Battery Percentage: ");
Serial.print(bat_percentage);
Serial.println(" %");

// Display temperature, humidity, battery voltage, and battery percentage on OLED display
display.clearDisplay();
display.setTextSize(2); // Increase text size
display.setTextColor(SSD1306_WHITE);
display.setCursor(0,0);
display.print(F("Batch 3"));
display.setTextSize(1); // Reset text size
display.setCursor(0, 20); // Adjust cursor position
display.print(F("Temp: "));
display.print(temperature);
display.print(F(" C"));
display.setCursor(0, 30); // Adjust cursor position
display.print(F("Humidity: "));
display.print(humidity);
display.print(F("%"));
display.setCursor(0, 40); // Adjust cursor position
display.print(F("Battery Voltage: "));
display.print(voltage);
display.print(F(" V"));
display.setCursor(0, 50); // Adjust cursor position
display.print(F("Battery Percentage: "));
display.print(bat_percentage);
display.print(F(" %"));
display.display();

// Send data to ThingSpeak
if (client.connect(server, 80)) {
  String postStr = apiKey;
  postStr += "&field1=";
  postStr += String(temperature); // Add temperature value
  postStr += "&field2=";
  postStr += String(humidity); // Add humidity value
  postStr += "&field3=";
  postStr += String(voltage); // Add battery voltage value
  postStr += "&field4=";
  postStr += String(bat_percentage); // Add battery percentage value
  postStr += "\r\n\r\n";

  client.print("POST /update HTTP/1.1\n");
```

```
    delay(100);
    client.print("Host: api.thingspeak.com\n");
    delay(100);
    client.print("Connection: close\n");
    delay(100);
    client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");
    delay(100);
    client.print("Content-Type: application/x-www-form-urlencoded\n");
    delay(100);
    client.print("Content-Length: ");
    delay(100);
    client.print(postStr.length());
    delay(100);
    client.print("\n\n");
    delay(100);
    client.print(postStr);
    delay(100);
  }
  client.stop();
  Serial.println("Sending....");
  delay(15000); // Delay between sending data to ThingSpeak
}

float mapfloat(float x, float in_min, float in_max, float out_min, float out_max) {
  return (x - in_min) * (out_max - out_min) / (in_max - in_min) + out_min;
}
```

CODE EXPLANATION:

This Arduino sketch is designed to read analog sensor values, calculate battery voltage and percentage, and then send this data to ThingSpeak, an IoT platform, for monitoring purposes. Below is a breakdown of the code:

```
#include <ESP8266WiFi.h>

// ThingSpeak API Key
String apiKey = "**************";

// WiFi credentials
const char* ssid =  "**************";       // Enter your WiFi Network's SSID
const char* pass =  "**************";       // Enter your WiFi Network's Password

// ThingSpeak server address
const char* server = "api.thingspeak.com";

// Analog pin for sensor input
int analogInPin  = A0;
```

// Variables to store sensor values and battery percentage

int sensorValue;

float calibration = 0.36; **// Calibration factor for battery voltage**

int bat_percentage;

// Create a WiFi client object

WiFiClient client;

void setup() { Serial.begin(115200); Serial.println("Connecting to ");Serial.println(ssid); WiFi.begin(ssid, pass);

// Wait for WiFi connection

while (WiFi.status() != WL_CONNECTED) {delay(100);

Serial.print("*");

}

Serial.println(""); Serial.println("WiFi connected");

}

void loop() {

// Read analog sensor value

sensorValue = analogRead(analogInPin);

// Convert sensor value to voltage

float voltage = (((sensorValue * 3.3) / 1024) * 2 + calibration); **// Voltage divider networkis 100K & 100K Resistor**

// Map voltage to battery percentage

bat_percentage = mapfloat(voltage, 2.8, 4.2, 0, 100); **// Battery Cut off Voltage: 2.8V,Maximum Voltage: 4.2V**

// Ensure battery percentage is within valid range

if (bat_percentage >= 100) {bat_percentage = 100;

}

if (bat_percentage <= 0) {bat_percentage = 1;

}

// Print sensor and battery information Serial.print("Analog Value = "); Serial.print(sensorValue);

Serial.print("\t Output Voltage = ");Serial.print(voltage);

```
Serial.print("\t Battery Percentage = ");Serial.println(bat_percentage); delay(1000);

// Connect to ThingSpeak and send data
if (client.connect(server, 80)) {String postStr = apiKey; postStr += "&field1="; postStr += String(voltage); postStr += "&field2=";
postStr += String(bat_percentage);postStr += "\r\n\r\n";

client.print("POST /update HTTP/1.1\n");delay(100);
client.print("Host: api.thingspeak.com\n");delay(100);
client.print("Connection: close\n");delay(100);
client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");delay(100);
client.print("Content-Type: application/x-www-form-urlencoded\n");delay(100);
client.print("Content-Length: ");
delay(100); client.print(postStr.length()); delay(100); client.print("\n\n"); delay(100); client.print(postStr); delay(100);
}
client.stop(); Serial.println("Sending. ");
delay(15000); // Send data every 15 seconds
}

// Function to map a float value
float mapfloat(float x, float in_min, float in_max, float out_min, float out_max) {return (x - in_min) * (out_max - out_min) / (in_max - in_min) + out_min;
}
```

Explanation:

- The code includes the ESP8266WiFi library to enable WiFi connectivity.
- WiFi credentials (SSID and password) and the ThingSpeak API key are defined.
- The server variable holds the address of the ThingSpeak server.
- An analog pin (A0) is designated for sensor input.
- sensorValue stores the analog sensor reading, and `calibration` adjusts for any discrepancies.
- battery percentage calculates the battery percentage based on the analog reading.
- In the setup() function:
- Serial communication is initiated.
- WiFi connection is established.
- In the loop() function:
- Sensor reading is obtained and converted to voltage.

- Voltage is mapped to a battery percentage.
- Data is sent to ThingSpeak in the specified format.
- Serial output displays the sensor reading, voltage, and battery percentage.
- Data transmission occurs every 15 seconds.
- mapfloat() is a custom function to map a float value from one range to another.

The key elements of this Arduino sketch in terms of libraries,connections, and data sources:

Library Used:

- ESP8266WiFi: This library enables the ESP8266 WiFi module to connect to a wireless network. It provides functions to establish a connection to a WiFi network and communicate over the internet.

Connection:

- WiFi Connection: The sketch connects to a WiFi network using the `WiFi.begin()` function,which takes the SSID and password of the network as parameters. It waits for the connection to be established using a `while` loop with `WiFi.status()` until `WL_CONNECTED`.

Data Sources:

- **Analog Sensor:** The system reads data from an analog sensor connected to pin A0. This sensor could be any analog sensor, such as a voltage sensor, temperature sensor, or light sensor.In the provided sketch, the assumption is that the sensor measures battery voltage.
- **Battery Voltage:** The voltage reading from the analog sensor is used to calculate the batterypercentage. This voltage reading is the primary data source for determining the battery status.

- **ThingSpeak:** ThingSpeak is an IoT platform that allows users to collect, visualize, and analyze data from sensors or devices. In this sketch, ThingSpeak is the destination for sendingthe battery voltage and percentage data. The ThingSpeak API key and server address are usedto establish a connection to the platform.

The sketch utilizes the ESP8266WiFi library to establish a WiFi connection, reads data from an analog sensor (assumed to measure battery voltage), and sends this data to the ThingSpeakplatform for remote monitoring and analysis. The WiFi connection provides internet access fordata transmission, and ThingSpeak serves as the data repository and visualization platform.

AUTOMATION SYSTEM USING THE NODEMCUESP8266 BOARD AND THE NEW BLYNK APP

MAIN CODE:

```
//Include the library files #define BLYNK_PRINT Serial#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

//Define the relay pins#define relay1 D0 #define relay2 D1
#define BLYNK_AUTH_TOKEN "" //Enter your blynk auth tokenchar auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "";//Enter your WIFI name char pass[] = "";//Enter your WIFI password

//Get the button valuesBLYNK_WRITE(V0) {
bool value1 = param.asInt();
// Check these values and turn the relay1 ON and OFFif (value1 == 1) {
digitalWrite(relay1, LOW);
} else {
digitalWrite(relay1, HIGH);
}
}

void setup() {
//Set the relay pins as output pinspinMode(relay1, OUTPUT); pinMode(relay2, OUTPUT);

// Turn OFF the relay digitalWrite(relay1, HIGH);digitalWrite(relay2, HIGH);

//Initialize the Blynk library
Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}
    void loop() {
//Run the Blynk libraryBlynk.run();
}
```

CODE EXPLAINATION:

// Include the required library files #define BLYNK_PRINT Serial #include <ESP8266WiFi.h> #include <BlynkSimpleEsp8266.h>
// Define the relay pins#define relay1 D0 #define relay2 D1
#define BLYNK_AUTH_TOKEN "" // Enter your Blynk auth tokenchar auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = ""; // Enter your WiFi name char pass[] = ""; // Enter your WiFi password
// Callback function to handle button widget state changes on virtual pin V0BLYNK_WRITE(V0) {
bool value1 = param.asInt();

```
// Check the state of the button and control relay1 accordinglyif (value1 == 1) {
digitalWrite(relay1, LOW); // Turn on relay1

} else {

digitalWrite(relay1, HIGH); // Turn off relay1

}


// Callback function to handle button widget state changes on virtual pin V1BLYNK_WRITE(V1) {
bool value2 = param.asInt();

// Check the state of the button and control relay2 accordinglyif (value2 == 1) {
digitalWrite(relay2, LOW); // Turn on relay2

} else {

digitalWrite(relay2, HIGH); // Turn off relay2

}

}

void setup() {

// Set the relay pins as output pinspinMode(relay1, OUTPUT); pinMode(relay2, OUTPUT);
// Turn off the relays initiallydigitalWrite(relay1, HIGH); digitalWrite(relay2, HIGH);
// Initialize the Blynk library with WiFi connection detailsBlynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}


void loop() {

// Run the Blynk libraryBlynk.run();
```

Explanation:

- The code is designed to work with the Blynk app, which is a platform for IoT projects. It'sintended for home automation, where users can control devices remotely via the Blynk app.

- The code begins by including the necessary libraries, `ESP8266WiFi` and
- `BlynkSimpleEsp8266`, required for WiFi connectivity and interfacing with the Blynk server.

- Relay pins `relay1` and `relay2` are defined as 'D0' and 'D1', respectively, assuming theyare connected to digital pins on the ESP8266.

- `BLYNK_AUTH_TOKEN` is defined as an empty string. Users should replace it with their Blynk authentication token obtained from the Blynk app.

- WiFi credentials (`ssid` and `pass`) are provided. Users should replace them with their WiFinetwork's SSID and password.
- Two callback functions (`BLYNK_WRITE(V0)` and `BLYNK_WRITE(V1)`) are defined tohandle changes in the state of buttons on virtual pins `V0` and `V1`. These buttons are assumedto be present on the Blynk app's user interface.
- In the `setup()` function:
- Relay pins are configured as output pins.
- Initially, the relays are turned off by setting their respective pins to HIGH.

CHAPTER 9: CONCLUSION AND FUTURE SCOPE

9.1 Conclusion

In conclusion, the integration of Solar Tracking and IoT Battery Monitoring with ESP8266 on ThingSpeak presents a comprehensive solution for optimizing solar energy utilization and enhancing battery management in sustainable energy systems. By dynamically adjusting solar panel orientation to maximize energy capture and remotely monitoring battery health parameters in real-time, this innovative approach ensures efficient energy production and storage. The utilization of the ThingSpeak platform facilitates seamless data collection, analysis, and visualization, empowering users with valuable insights into system performance and enabling proactive maintenance strategies. Through enhanced reliability, increased efficiency, and remote accessibility, this integrated solution offers significant advantages across residential, commercial, industrial, and rural applications, paving the way for a greener and more sustainable energy landscape. Moving forward, continued advancements in technology and widespread adoption of such integrated systems hold the potential to drive meaningful progress towards achieving global energy sustainability goals. Overall, Solar Tracking & IoT Battery Monitoring with ESP8266 on ThingSpeak offers a holistic solution for sustainable energy management, contributing to reduced electricity costs, enhanced reliability, and minimized environmental impact. With continued advancements in technology and implementation, this solution holds promise for widespread adoption across residential, commercial, industrial, and rural

applications, ultimately paving the way towards a cleaner and more sustainable energy future.

9.2 Future Scope

The future scope for Solar Tracking & IoT Battery Monitoring with ESP8266 on ThingSpeak holds immense promise, with several avenues for further development and enhancement. Some of the key areas of future exploration and advancement include:

1. **Advanced Analytics and Machine Learning Integration**: Incorporating advanced analytics techniques, such as machine learning algorithms, can further optimize energy management strategies by predicting energy production patterns, identifying anomalies, and recommending optimal system configurations.

2. **Integration with Renewable Energy Sources**: Expanding the scope of the system to integrate with other renewable energy sources, such as wind or hydroelectric power, can create hybrid energy systems that offer enhanced reliability and resilience.

3. **Energy Trading and Peer-to-Peer Energy Sharing**: Implementing mechanisms for energy trading and peer-to-peer energy sharing can enable users to buy, sell, or exchange excess energy generated by their solar systems, fostering community-based energy initiatives and promoting energy self-sufficiency.

4. **Enhanced Remote Control and Automation**: Developing advanced remote control and automation features, such as predictive maintenance scheduling and adaptive energy management algorithms, can further streamline system operation and optimize energy utilization based on changing environmental conditions and user preferences.

5**. Integration with Smart Grid Technologies**: Integrating Solar Tracking & IoT Battery Monitoring systems with smart grid technologies can enable bi-directional communication between energy consumers, producers, and grid operators, facilitating dynamic energy pricing, demand response, and grid balancing.

6. **Expansion of Application Domains**: Exploring new application domains, such as transportation electrification, smart cities, and decentralized microgrids, can unlock novel opportunities for deploying Solar Tracking & IoT Battery Monitoring systems in diverse contexts, thereby accelerating the transition towards a sustainable energy future.

7. **Standardization and Interoperability**: Establishing industry standards and protocols for interoperability between different components and systems can promote compatibility, scalability, and interoperability, facilitating seamless integration and deployment of Solar Tracking & IoT Battery Monitoring solutions across diverse environments and use cases.

8. **Cost Reduction and Affordability**: Continued research and development efforts aimed at reducing the cost of hardware components, improving energy efficiency, and optimizing system design can enhance the affordability and accessibility of Solar Tracking & IoT Battery Monitoring solutions, making them more widely accessible to a broader range of users.

In essence, the future of Solar Tracking & IoT Battery Monitoring with ESP8266 on ThingSpeak is characterized by continuous innovation, collaboration, and adaptation to emerging technological trends and market dynamics. By leveraging advancements in analytics, integration, and automation, these systems have the potential to play a pivotal role in reshaping the global energy landscape and driving the transition towards a sustainable, decentralized, and resilient energy infrastructure.

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