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Battery And Weather Monitoring System

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***Abstract* - We plan to create a Battery & Weather Monitoring System using Node MCU (ESP 8266) and Thing speak Cloud. This system will allow us to monitor the battery voltage and percentage and humidity and temperature of the battery and remotely from anywhere in the world. It is particularly useful for keeping track of the battery charging or discharging status. Since the battery is the main component that powers any system or device, it is crucial to keep an eye on its voltage level. Improper charging and discharging can lead to battery damage or system failure. Most of the electrical or electronic devices have a Battery Monitoring System (BMS) that monitors all the battery properties such as voltage, current, and temperature to ensure the safe handling of Lithium-Ion batteries.**

***Keywords* – MCU, BMS, Lithium-Ion, Batteries, Temperature, Weather Monitoring.**

I INTRODUCTION

A Battery Monitoring System (BMS) is a critical is a critical component in modern energy storage solutions, providing essential monitoring and control functions for batteries. With the increasing demand for reliable and efficient energy storage across various industries, the introduction of a BMS ensures optimal performance, safety and longevity of battery systems. By constantly monitoring parameters such as Voltage, Current, Temperature, and State of Charge, The BMS helps prevent overcharging, over discharging and Overheating, Which can degrade battery health and pose safety risks. Moreover, advanced BMS designs incorporate intelligent algorithms and communication protocols to enable real time data analysis, fault detection, and remote management, enhancing overall system efficiency and reliability. As renewable energy source and Electric Vehicles become more prevalent, the integration of a robust BMS becomes imperative to maximize the utilization and sustainability of battery technologies, contributing to a cleaner and more resilient energy infrastructure.

A Battery Management System (BMS) is a critical component in modern battery- powered applications, ranging from electric vehicles to renewable energy storage systems. Essentially, it serves as the guardian of the battery pack, ensuring optimal performance, safety, and longevity.

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The primary functions of a BMS include monitoring individual cell voltages and temperatures, balancing cell capacities, controlling charging and discharging currents, and providing crucial data to the user or system controller. By actively managing these parameters, a BMS safeguards against overcharging, over-discharging, and thermal runaway, which can lead to reduced battery life, performance degradation, or even safety hazards such as fire or explosion. With the rapid advancement of battery technology and the increasing demand for reliable energy storage solutions, the role of BMS continues to evolve, incorporating advanced algorithms, communication protocols, and integration with broader energy management systems to maximize efficiency and reliability.

In addition to its core functions, a BMS often incorporates sophisticated algorithms for state- of-charge (SoC) and state-of-health (SoH) estimation, which are crucial for accurately gauging the available energy and predicting the battery's remaining lifespan. These estimations enable users to make informed decisions about usage patterns, charging strategies, and maintenance schedules, optimizing the overall efficiency and longevity of the battery system.
Furthermore, BMS units are typically equipped with various protective features to mitigate risks associated with battery operation. These may include overcurrent protection, short-circuit detection, and insulation monitoring to prevent damage caused by electrical faults or external influences. Moreover, advanced BMS designs incorporate fail-safe mechanisms and redundancy to ensure continuous operation even in the event of component failure, thereby enhancing overall system reliability.

The role of BMS extends beyond individual battery packs to encompass broader system- level management. In complex applications such as electric vehicles or grid-connected energy storage systems, multiple battery packs may be interconnected to form a larger energy storage unit. In such cases, the BMS orchestrates the coordination of charging, discharging, and balancing operations across all interconnected packs, optimizing overall system performance and ensuring uniform wear among individual cells.

Additionally, with the growing emphasis on sustainability and environmental responsibility, BMS units are increasingly integrated with smart grid technologies and renewable energy sources such as solar and wind. By intelligently managing the flow of energy between batteries, renewable sources, and the grid, BMS units contribute to the efficient utilization of clean energy resources and support the transition towards a more sustainable energy ecosystem.

II LITERATURE REVIEW

Research problem identified

In this all paper we have identified that all are using a display unit for displaying the Voltage, Temperature, Humidity and Battery Percentage and But in our project we are using a Thing speak Cloud to shows the details required related to the Battery and Thing speak Cloud has a storage Capacity in it.

A. Battery Management System in Electric Vehicles

Title: Battery Management System in Electric Vehicles

Authors: Sandeep, Priyanka, Shekar, and Ravi.

Methodology: Energy and Environment problems are the most dangerous problems faced by the world automotive industry to overcome these problems world has accelerated to the new energy development.

Result: Based on this work, specific challenges faced by BMS and their Solutions were presented as a foundation for future research. Based on the particular situation, different strategies can be applied to upgrade and optimize the performance of Bini EV"S.

Gap identified: Here we are using a DHT 22 sensor for indicating a Temperature and Humidity and Think speak Cloud to shows the final results.

Summary: A Battery Management System (BMS), which Manages the electronics of a Rechargeable battery whether a cell or a battery pack, thus becomes a crucial factor in ensuring electric vehicle safety. It safeguards the us and the battery by ensuring that the cell operates with in its safe operating parameter.

B. Battery Monitoring System

Title: Battery Monitoring System

Authors: Chandrasekhar, Mahajan, Sarvesh koli, Komal Bhat, Prerana Kokate, Bhagwat Kolekar, Siddhant Kolhe.

Methodology: The NodeMCU ESP8266 module only supports the input analog voltage of 3.3 volts but the battery we are using her, in this case is 4.4 volts with a cut of voltage of 2.8 volts. To tackle this problem, we formed a voltage divider circuit to lower the input analog voltage.

Result: The battery in any system/device is the main component because it powers the entire system. For that reason, we need to monitor the voltage level of the battery. We all know that an improper system of charging and discharging a battery may lead to battery damage or system failure.

Gap identified: The gap between this paper and our project is here we are using a\i DHT 22 sensors for indicating a Temperature and Humidity and Think speak Cloud to shows the final results

Summary: A BMS"s functional safety is its primary concern. Avoiding the voltage, current and temperature of each and every cell under supervisory control from exceeding specified SOA limits is crucial during charging and discharging operations

C. IOT Based Battery monitoring system for Electric vehicle

Title: IOT Based Battery monitoring system for Electric vehicle

Authors: Mohd HelmyabdWahab, Radzi Ambar, Aslina Baharum, Hafizul Fahri Hanafi.

Methodology: The lithium- ion battery's voltage level. At the same time, a SIM808 GSM/GPS/GPRS shield reads the location of the vehicle by using the GPS function. The battery's voltage level readings and location of the vehicle are conveyed to an Arduino Uno microcontroller for processing.

Result: The paper describes the design and development of an IOT based battery monitoring system for EV to ensure the battery performance degradation can be monitoring on line. The Objective is to proof that the concept of the idea can be realized.

Gap identified: The gap between this paper and our project is here we are using a\i DHT 22 sensors for indicating a Temperature and Humidity and Think speak Cloud to shows the final results

Summary: The Summary of this paper is the developed battery monitoring system is also consisting of a web-based user interface. The user interface is capable to monitor multiple battery monitoring device's location and conditions of batteries.

III EXISTING METHOD

A battery and weather monitoring system typically comprises various components and methodologies to ensure effective functionality. At its core, the system incorporates sensors to measure weather parameters such as temperature, humidity, and atmospheric pressure. These sensors are strategically placed to provide accurate readings representative of the surrounding environment. Additionally, the system includes sensors to monitor the status of the battery, including its voltage, current, and temperature.

Data from these sensors are collected and processed by a central control unit or microcontroller, which may employ algorithms to analyze the information and detect any anomalies or potential issues. This control unit often communicates with a display interface or remote monitoring platform to present real-time data to users, allowing them to monitor the condition of both the battery and the surrounding weather.

Furthermore, the system may incorporate predictive modeling or machine learning algorithms to forecast battery performance based on weather conditions. This proactive approach enables users to anticipate potential challenges and optimize battery usage accordingly, thereby enhancing overall efficiency and reliability.

Overall, through the integration of sensors, data processing units, and communication interfaces, a Battery and weather monitoring system provides invaluable insights into the status of both the battery and the Environment, enabling informed decision-making and proactive maintenance strategies.

IV PROPOSING METHOD

A novel approach to a battery and weather monitoring system entails leveraging advanced sensor technology and data analytics for enhanced accuracy and efficiency. The system would incorporate a network of high-quality weather sensors to capture real-time data on various environmental parameters, including temperature, humidity, atmospheric pressure, and solar radiation. These sensors would be strategically deployed across the monitoring area to ensure comprehensive coverage and reliable data collection.

In tandem, the system would integrate state-of-the-art battery monitoring sensors to track key metrics such as voltage, current, temperature, and state of charge. These sensors would be designed to provide precise and continuous monitoring of battery performance, enabling early detection of potential issues such as overcharging, over-discharging, or temperature extremes.

To process and analyze the vast amount of data collected by the sensors, the system would employ advanced data analytics techniques, including machine learning algorithms and predictive modeling. By analyzing historical weather patterns and battery performance data, the system could generate accurate forecasts and predictive insights regarding battery behavior under different weather conditions. This predictive capability would empower users to optimize battery usage, anticipate maintenance needs, and mitigate risks associated with adverse weather events.

Furthermore, the system would feature a user-friendly interface accessible via web or mobile applications, allowing stakeholders to monitor real-time weather and battery data, receive alerts for critical events or anomalies, and access historical performance records. This interface would provide intuitive visualization tools, customizable dashboards, and data analytics capabilities, enabling users to make informed decisions and take proactive measures to optimize battery performance and ensure operational resilience.

V METHODLOGY

Block Diagram

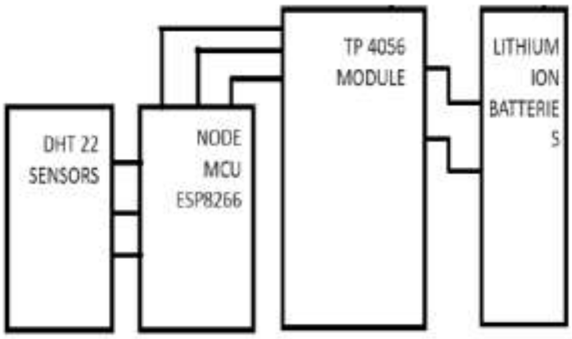

Fig 5.1: Block of Battery and Weather Monitoring System.

Components
1. NODEMCU (ESP8266)
2. LITHIUM ION BATTERY
3. RESISTORS
4. TP4056 MODULE
5. DHT 22 SENSORS
6. JUMPER WIRES
7. PCB BOARD

EQUIPMENT DETAILS

1. NODEMCU (ESP8266)

Overall, by combining advanced sensor technology, data analytics, and user-friendly interface design, this proposed battery and weather monitoring system offers a comprehensive solution for monitoring and managing battery assets in diverse environmental conditions. Its predictive capabilities and proactive approach empower users to optimize performance, enhance reliability, and minimize downtime, ultimately driving operational efficiency and cost savings. The ESP8266 is a system on a chip (SOC) Wi-Fi microchip for Internet of Things (IOT) applications produced by Espressif Systems. Given its low cost, small size and adaptability with embedded devices, the ESP8266 is now used extensively across IoT devices.

The NodeMCU (Node Micro Controller Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

However, as a chip, the ESP8266 is also hard to access and use. You must solder wires, with the appropriate analog voltage, to its pins for the simplest tasks such as powering it on or sending a keystroke to the “computer” on the chip. You also have to program it in low-level machine instructions that can be interpreted by the chip hardware. This level of integration is not a problem using the ESP8266 as an embedded controller chip in mass-produced electronics. It is a huge burden for hobbyists, hackers, or students who want to experiment with it in their own IoT projects.

Fig 5.2: NodeMCU (ESP8266)

Lithium-Ion Batteries

Lithium-ion batteries power the lives of millions of people each day. From laptops andcell phones to hybrids and electric cars, this technology is growing in popularity due to its light weight, high energy density, and ability to recharge.

A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible intercalation of Li^+ ions into electronically conducting solids to store energy. In comparison with other commercial rechargeable batteries, Li-ion batteries are characterized by higher specific energy, higher energy density, higher energy efficiency, a longer cycle life, and a longer calendar life. Also noteworthy is a dramatic improvement in lithium-ion battery properties after their market introduction in 1991: within the next 30 years, their volumetric energy density increased threefold while their cost dropped tenfold.

The invention and commercialization of Li-ion batteries may have had one of the greatest impacts of all technologies in human history, as recognized by the 2019 Nobel Prize in Chemistry. More specifically, Li-ion batteries enabled portable consumer electronics, laptop computers, cellular phones, and electric cars, or what has been called the e-mobility revolution. It also sees significant use for grid-scale energy storage as well as military and aerospace applications. Lithium-ion cells can be manufactured to optimize energy or power density. Handheld electronics mostly use lithium polymer batteries (with a polymer gel as an electrolyte), a lithiumcobalt oxide ($LiCoO_2$) cathode material, and a graphite anode, which together offer high energy density. Lithium iron phosphate ($LiFePO_4$), lithium manganeseoxide ($LiMn_2O_4$ 20 spinel,or Li_2MnO_3 - based lithium-rich layered materials, LMR- NMC), and lithium nickel manganese cobalt oxide ($LiNiMnCoO_2$ or NMC) may offer longer life and a higher discharge rate. NMC and its derivativesare widely used in the electrification of transport, one of the main technologies (combined with renewable energy) for reducing greenhouse gas emissions from vehicles.

Fig 5.3: Lithium-ion battery

Specification of a Lithium Ion Battery

A 4300mAh lithium-ion battery is a type of rechargeable battery commonly used in various electronic devices, including smartphones, tablets, laptops, and other portable gadgets. Here are some typical specifications you might find for such a battery:

Capacity: The capacity of 4300mAh means it can theoretically deliver a current of 4300 mill ampere-hours for one hour. This capacity determines how long the battery can power a device before needing recharging.

Voltage: Lithium-ion batteries typically have a nominal voltage of 3.7 volts, though this can vary slightly depending on the specific chemistry and design.Chemistry: Lithium-ion batteries use lithium ions to transfer charge between the positive and negative electrodes. This chemistry offers a good balance between energy density, weight,and rechargeability.

1. Cycle Life: The number of charge-discharge cycles a lithium-ion battery can endure before its capacity significantly decreases. Higher quality batteries can typically withstand more cycles.

2. Operating Temperature: Lithium-ion batteries have optimal operating temperatures. Charging or discharging them outside of these ranges can degrade performance and reduce lifespan.

3. Charging Rate: Lithium-ion batteries should be charged within certain current limits to ensure safety and longevity. Fast charging technologies may allow for higher charging rates, but this can also increase heat generation and potentially degrade the battery over time.

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4. Dimensions and Weight: These batteries come in various sizes and shapes depending on the device they are intended for. Weight can also vary depending on the specific chemistry and design.

5. Safety Features: Lithium-ion batteries often include built-in safety features to prevent overcharging, over-discharging, and overheating, which can lead to safety hazards such as fires or explosions.
It's important to note that the actual performance and characteristics of a battery can vary depending on the specific manufacturer, quality of materials, and usage conditions. Always refer to the manufacturer's specifications and recommendations for the specific battery you're interested in.

CIRCUIT DIAGRAM

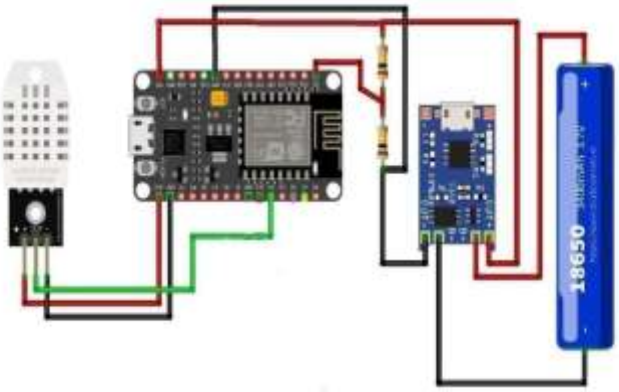

Fig 5.4: Circuit Diagram

PROCEDURE

A battery management system (BMS) utilizing the ESP8266 microcontroller typically involves several key steps to effectively monitor and manage battery performance. Initially, the ESP8266 connects to various sensors such as voltage, current, and temperature sensors, which are interfaced with the battery cells or packs. These sensors provide real-time data on the battery's state, including voltage levels, current flow, and temperature variations. The ESP8266 then processes this data, employing algorithms to calculate parameters such as state of charge (SoC), state of health (SoH), and state of function (SoF) to assess the battery's condition accurately. Additionally, the ESP8266 communicates with external devices or systems, such as displays or IoT platforms, to provide users with relevant information about the battery status. Furthermore, the BMS employing ESP8266 often incorporates safety features like overcharge protection, over- discharge protection, and temperature monitoring to prevent hazardous situations and prolong battery lifespan. Finally, through its connectivity capabilities, the ESP8266 enables remote monitoring and control of the battery system, allowing users to access real-time data and adjust settings as needed, enhancing overall battery performance and safety. To implement a battery management system (BMS) using ESP8266, follow these steps:

Firstly, gather the necessary components including an ESP8266 microcontroller, battery voltage sensor, current sensor (if required), relay module (for controlling charging/discharging), and any additional sensors for temperature or other parameters you want to monitor.
Next, start by setting up the hardware. Connect the battery voltage sensor and current sensor to the appropriate pins on the ESP8266. Ensure proper connections and consider using voltage dividers if needed to scale down voltage levels to within the ESP8266's operating range.

Then, move on to coding the ESP8266 firmware. Utilize the Arduino IDE or any other suitable development environment. Begin by configuring the ESP8266 to read data from the voltage and current sensors periodically. Implement algorithms to calculate parameters such as state of charge (SoC), state of health (SoH), and remaining battery capacity based on the sensor readings

Integrate logic to control charging and discharging processes. Depending on your application, this may involve activating/deactivating a relay connected to the charging source (e.g., solar panel, mains supply) and load (e.g., motor, appliances) based on predefined conditions such as battery voltage, current, and temperature.

Implement safety features to prevent overcharging, over-discharging, and overheating of the battery. This may include setting thresholds for voltage and current levels, as well as incorporating temperature monitoring and cutoff mechanisms.

Consider adding Wi-Fi connectivity to enable remote monitoring and control of the BMS. This allows you to access real-time data and receive alerts or notifications in case of any abnormal conditions.

Test the system thoroughly to ensure its reliability and effectiveness. Monitor its performance over time and make adjustments to the code as necessary to optimize its operation and address any issues that arise.

Finally, consider packaging the hardware components into a suitable enclosure for protection against environmental factors and mounting it securely in the desired location.
By following these steps, you can create a battery management system using ESP8266 that effectively monitors, controls, and protects your battery system. Certainly! Here's an expanded version:
To initiate the development of a battery management system (BMS) leveraging the ESP8266 microcontroller, begin with a comprehensive understanding of your requirements and the characteristics of the battery you intend to manage. Define parameters such as battery chemistry, voltage ratings, capacity, and the expected operating conditions.

Proceed with assembling the hardware components required for the BMS setup. This typically includes the ESP8266 microcontroller board, battery voltage sensor, current sensor (if needed for monitoring charging/discharging currents), relay module (for controlling charging/discharging), and any additional sensors deemed necessary for monitoring parameters like temperature or humidity.

With the hardware ready, move on to the software development phase. Set up your development environment, such as the Arduino IDE, and configure it to work with the ESP8266 microcontroller. Write the firmware code to initialize the ESP8266, configure pins for sensor interfacing, and establish communication protocols.

Implement sensor reading routines to acquire data from the voltage and current sensors. Apply appropriate calibration techniques to ensure accurate readings, considering factors like sensor accuracy and signal conditioning. Develop algorithms to process sensor data and calculate critical parameters such as state of charge (SoC), state of health (SoH), remaining battery capacity, and estimated time to full/empty. These calculations may involve integrating voltage and current measurements over time, considering battery discharge characteristics, and compensating for temperature effects.

Incorporate control logic to manage charging and discharging processes effectively. Based on the calculated battery parameters and user-defined thresholds, control the relay module to regulate the flow of current from the charging source to the battery and from the battery to the load.

Implement safety mechanisms to protect the battery from harmful conditions such as overcharging, over-discharging, and overheating. Set up voltage and current thresholds for triggering charging/discharging actions and incorporate temperature monitoring with appropriate cutoff mechanisms. Integrate Wi-Fi connectivity features using the ESP8266's built-in capabilities. Enable remote monitoring and control of the BMS through a web interface or mobile application. Develop features for real-time data visualization, historical logging, and alert notifications to keep users informed about the battery's status.

Conduct rigorous testing of the BMS prototype to validate its functionality, reliability, and performance under various operating scenarios. Evaluate its response to different charging profiles, load conditions, and environmental factors. Refine the firmware code and hardware design based on test results and user feedback. Optimize the BMS for efficiency, responsiveness, and energy consumption, aiming for a balance between functionality and resource utilization.
Once satisfied with the prototype's performance, consider packaging the components into a compact, durable enclosure suitable for deployment in the intended environment. Ensure proper insulation and protection against moisture, dust, and physical damage.

Document the BMS design, including hardware schematics, firmware source code, and operational guidelines, for future reference and replication. Provide user manuals and support documentation to assist users in installing, configuring, and maintaining the BMS system effectively.

Think Speak

Introduction

The Internet of Things(IoT) is a system of „connected things". The things generally comprise of an embedded operating system and an ability to communicate with the internet or withthe neighbouring things. One of the key elements of a generic IoT system that bridges the various„things" is an IoT service. An interesting implication from the „things" comprising the IoT systems is that the things by themselves cannot do anything. At a bare minimum, they should have an ability to connect to other „things". But the real power of IoT is harnessed when the things connect to a „service" either directly or via other „things". In such systems, the service plays the role of an invisible manager by providing capabilities ranging from simple data collection and monitoring to complex data analytics. The below diagram illustrates where an IoT service fits in an IoT ecosystem

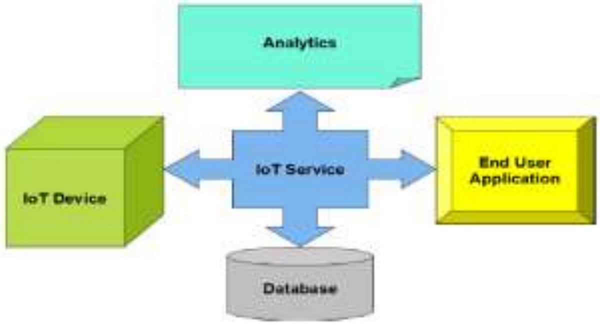

Fig 5.5: Diagram of IoT services

VI RESULTS

The implementation of a battery and weather monitoring system yields multifaceted benefits, revolutionizing resource management and operational efficiency. By seamlessly integrating battery performance monitoring with real-time weather data collection, the system empowers users to optimize energy usage, prolong battery life, and enhance system reliability. This holistic approach enables proactive maintenance scheduling, informed decision-making, and improved asset performance across diverse applications. Additionally, the system's advanced analytics capabilities facilitate predictive modeling and trend analysis, enabling stakeholders to anticipate and mitigate potential risks associated with fluctuating environmental conditions. As a result, organizations can achieve significant cost savings, reduced downtime, and heightened resilience, ultimately advancing sustainability goals and ensuring uninterrupted operation in dynamic operational landscapes.

The implementation of a battery and weather monitoring system not only enhances operational efficiency but also fosters sustainability and resilience across various sectors. By continuously monitoring battery performance metrics such as state of charge, voltage, and temperature, alongside real-time weather data such as temperature, humidity, and solar radiation, the system provides a comprehensive understanding of energy dynamics and environmental conditions. This comprehensive insight enables organizations to optimize energy usage, effectively manage energy storage, and reduce overall energy consumption, leading to significant cost savings and environmental impact reduction. Moreover, by proactively identifying potential issues such as extreme weather events or battery degradation, the system allows for timely interventions, minimizing downtime and maximizing system reliability. Beyond immediate operational benefits, the data collected by the system can inform long-term strategic planning, enabling organizations to adapt to evolving energy and climate challenges. Consequently, the battery and weather monitoring system serves as a cornerstone for building sustainable, resilient, and future-proof infrastructure in both urban and remote environments.

Fig6.1: Output snap of the Battery and Weather Monitoring system

CONCLUSION

The integration of a battery and weather monitoring system offers a comprehensive solution for both energy management and environmental data collection. By combining these functionalities, users can efficiently monitor energy storage levels while simultaneously gathering critical weather data such as temperature, humidity, and solar radiation. This integrated approach not only ensures reliable power supply for various applications but also enables informed decision-making based on real-time environmental conditions. With advanced analytics and remote accessibility features, this system provides a seamless and scalable solution for optimizing energy usage and enhancing resilience in diverse operational environments.

The battery and weather monitoring system represents a significant advancement in resource management and risk mitigation strategies. Through continuous monitoring of battery performance metrics such as charge level, voltage, and health status, coupled with real-time weather data acquisition, users can anticipate and respond proactively to changing environmental conditions. This synergy enables enhanced energy efficiency, proactive maintenance scheduling, and improved asset longevity. Moreover, the system's data-driven insights empower users to optimize energy consumption patterns, minimize downtime, and ultimately reduce operational costs. With its user- friendly interface and robust functionality, the integrated system offers a versatile solution adaptable to various industries and applications, from renewable energy installations to remote infrastructure monitoring, ensuring reliable performance and sustainability in dynamic operating environments.

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