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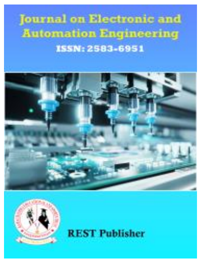

Battery Monitoring System for Lithium- Ion Batteries Using IOT

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Abstract: *The increasing adoption of electric vehicles (EVs) has highlighted the need for an efficient Battery Monitoring System (BMS) to ensure the safe and reliable operation of lithium-ion batteries. This project presents an IoT-based BMS that provides real-time monitoring of critical battery parameters such as voltage, charge level, and estimated remaining time. The system integrates hardware components, including an ATmega328 microcontroller, voltage sensors, an ESP8266 Wi-Fi module, and a GPS module, to collect and transmit data to a cloud-based platform. A mobile application, developed using MIT App Inventor, enables users to access battery status remotely, receive low battery alerts, and locate the nearest charging stations via GPS. The proposed system aims to enhance battery safety, optimize energy usage, and provide a user-friendly interface for EV owners. Testing results indicate improved user awareness and proactive battery management, making the system a valuable solution for modern electric mobility applications.*

Key words: *Battery Monitoring System (BMS), Electric Vehicles (EVs), Lithium-Ion Batteries, Internet of Things (IoT), Temperature Sensor, Push Button, Real-Time Data Monitoring, MIT App Inventor, Charging Station Locator, Remote Monitoring Systems.*

1. INTRODUCTION

The global shift towards electric vehicles (EVs) has gained significant momentum due to increasing environmental concerns and rising fuel costs. As a result, there is a growing demand for efficient and reliable battery management systems (BMS) to ensure the optimal performance and longevity of lithium-ion batteries, which are widely used in EVs. Lithium-ion batteries are favored due to their high energy density, longer lifespan, and lightweight nature compared to other battery technologies such as lead-acid or nickel-metal hydride batteries. Despite their advantages, lithium-ion batteries pose several challenges, including the risks of overcharging, deep discharging, and thermal runaway, all of which can impact the battery's lifespan, performance, and safety. To address these challenges, a comprehensive and intelligent battery monitoring system is essential to continuously track battery health, ensure efficient energy usage, and provide real-time feedback to users and service providers.

Problem Statement: With the increasing reliance on lithium-ion batteries in EVs, several critical issues arise that can affect their operational efficiency and user experience. The primary challenges include the lack of real-time monitoring of battery parameters, leading to unforeseen failures and reduced efficiency. Additionally, users often do not receive timely notifications regarding battery health and charging status, which can result in vehicle breakdowns due to depleted battery levels. Another major concern is the absence of a guiding mechanism to locate nearby charging stations, which can leave users stranded, especially in unfamiliar areas. These challenges highlight the necessity for an advanced IoT-based solution that offers seamless monitoring, timely alerts, and intelligent navigation to optimize battery performance and enhance user convenience.

Objective: The primary objective of this project is to develop an IoT-based Battery Monitoring System (BMS) that provides real-time data acquisition, monitoring, and control of lithium-ion batteries used in electric vehicles. This system aims to enhance battery efficiency and longevity by providing users with critical insights into battery health, usage patterns, and predictive maintenance.

The key objectives include:
The project focuses on developing a comprehensive battery monitoring and management system, designed to continuously track essential battery parameters such as voltage, current, temperature, and state of charge (SoC). By integrating a Battery Management System (BMS), sensors will measure these key metrics in real-time, ensuring safe operation and optimal performance. In addition, the system will include user alerts and notifications to promptly notify users of potential issues, such as low battery levels, abnormal operating conditions, or the need for maintenance. These alerts will be delivered via push notifications through a mobile app, ensuring users are always informed. Furthermore, the system will feature GPS functionality for navigation assistance, enabling users to locate the nearest charging stations based on their current location and battery status. The app will calculate the distance to the nearest charging station and provide turn-by-turn directions. To enhance decision-making and predictive maintenance, cloud-based data management will store real-time data for analysis, allowing users to access their battery information remotely and track performance history. The data will also help with predictive analytics to anticipate maintenance needs. Finally, the user interface will be optimized for ease of use, with a mobile application that offers a simple and intuitive way for users to monitor their battery status, view maintenance alerts, and access essential information about their device's battery health. This integrated system will improve user experience and provide valuable insights into battery performance, enhancing overall efficiency and reliability.

2. EXISTING SYSTEM

Traditional Battery Management Systems (BMS): Monitors basic parameters like voltage, current Lacks advanced IoT integration for remote monitoring or data analytics

IoT-Enabled Monitoring Solutions: Use of sensors and IoT platforms for real-time data acquisition, visualization. Limited focus on predictive maintenance or advanced decision-making

Cloud-Based Systems: Cloud storage is utilized for logging battery data, enabling remote access. Often lacks real-time feedback and comprehensive analytics for users.

Disadvantages: No temperature monitoring for battery, No manual triggering

3. PROPOSED SYSTEM

Develop an intelligent IoT-based Battery Monitoring System (BMS) for real-time monitoring, predictive maintenance, and user assistance.Key features are real-time data acquisition, alerts and notifications, cloud integration, navigation assistance.In this system we will also have features like charging left, remaining distance that can be covered, location of vehicle etc.System architecture consists of sensors, microcontrollers, cloud platform, mobile application.components used are Lithium-ion battery, voltage sensor, ESP 8266 Wi-Fi module, GPS module, LCD display, ATmeg328 microcontroller, Google firebase.

Block Diagram: The Battery is monitored by a Voltage Sensor, which measures its voltage and displays it on an LCD DisplayThe ATmega 328 microcontroller processes the voltage data received from thesensor.The ESP8266Wi-Fi module transmits the processed data to a Cloud Database for remote access.Mobile Application retrieves battery data from the cloud, providing real-time updates.The mobile app sends User Alerts based on battery status and integrates with GPS Navigation for guidance.

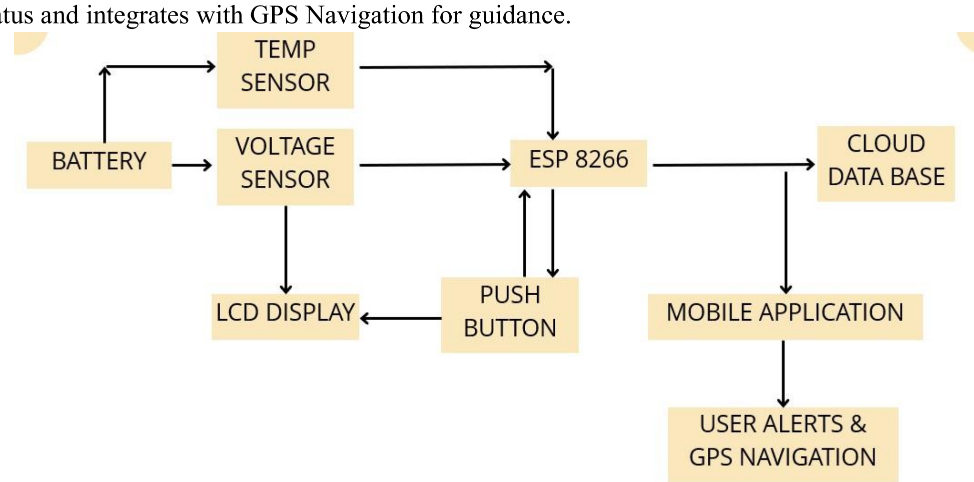

FIGURE 1. Block diagram of proposed system

Components used:

- Lithium-Ion Batteries
- Voltage Sensor
- ESP8266 Wi-Fi Module
- 16*2 Lcd Display
- DHT-11Sensor
- Cloud Computing
- GPS Integration
- MIT App Inventor

Lithium ion batteries: Lithium-ion batteries are the dominant technology for powering electric vehicles (EVs) due to their high energy density, long cycle life, and lightweight design, enabling EVs to achieve longer ranges and efficient performance.

FIGURE 2. lithium-ion batteries

High Energy Density: Lithium-ion batteries can store a significant amount of energy for their size and weight, crucial for achieving a good driving range in EVs.
Long Cycle Life: They can withstand numerous charge-discharge cycles without significant degradation, ensuring durability and longevity for EV use.
Lightweight: Their relatively low weight compared to other battery technologies is important for overall vehicle weight and efficiency.
Fast Charging: Lithium-ion batteries are capable of fast charging, allowing EVs to quickly replenish their energy.
Rechargeable: They are rechargeable, enabling them to be used repeatedly, which is essential for electric vehicle operation.

Voltage Sensor:

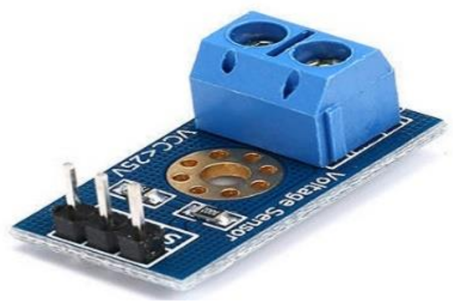

FIGURE 3. voltage sensor

In electric vehicles (EVs), voltage sensors are crucial for monitoring battery health, ensuring safe and efficient operation, and preventing overcharging or damage. They measure the voltage magnitude of the high-voltage battery, often using resistive dividers, and are essential for Battery Management Systems (BMS) to judge the battery's state**.**
Battery Health: They help the BMS determine the battery's state of charge (SOC) and state of health (SOH).
Safety: By detecting voltage fluctuations, they help prevent overcharging, over-discharging, and other potentially dangerous situations.
Efficiency: Accurate voltage readings enable the BMS to optimize charging and discharging processes, maximizing range and efficiency.

ESP-8266 WIFI module:

FIGURE 4. ESP-8266 WIFI Module

The **ESP8266 WiFi module** is a popular and inexpensive WiFi module used in various IoT (Internet of Things) projects. It provides a way to add WiFi capabilities to microcontrollers like Arduino or Raspberry Pi, allowing them to connect to a WiFi network and send or receive data over the internet.

Key Features of the ESP8266:
WiFi Connectivity: It supports IEEE 802.11 b/g/n WiFi standards, which allow it to connect to WiFi networks.
Low Power Consumption: The ESP8266 is designed for low power consumption, which makes it ideal for battery-powered devices.
Wide Range of Applications: It's used in smart home devices, automation, sensors, and other IoT applications.
Programmable: It can be programmed directly using the Arduino IDE, ESP-IDF (Espressif IoT Development Framework), or NodeMCU (Lua script).

16*2 Lcd Display:
16x2 LCD display is one of the most commonly used displays in electronics projects. The "16x2" refers to the number of characters that the display can show—16 characters per row and 2 rows. This kind of display is often used for showing text-based information, making it ideal for projects like temperature sensors, clocks, or other information displays.
Key Features of a 16x2 LCD Display:
16 Characters per Row: You can display up to 16 characters on each of the two rows.
2 Rows: Two lines of text can be shown at once, with each row supporting 16 characters.
Character-based Display: Each pixel in the display represents a single character, and you can't display images directly.
Backlight: Most 16x2 LCD displays have a backlight, which can be turned on or off to make the text visible in different lighting conditions.
Interface: They usually communicate over I2C (a two-wire interface), or parallel, and most commonly use the HD44780 controller.

DHT 11 Sensor:

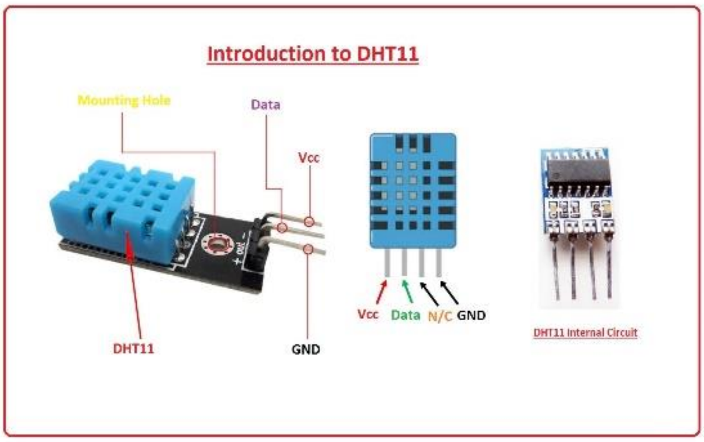

FIGURE 5. DHT-11 Sensor

The DHT11 is a low-cost digital temperature and humidity sensor commonly used in electronic projects for

measuring environmental conditions. It's widely used in IoT and home automation projects, and it's relatively simple to interface with microcontrollers like Arduino, Raspberry Pi, etc.
Key Features of the DHT11 Sensor:
Temperature Measurement:
Temperature range: 0 to 50°C (with a ±2°C accuracy).
It outputs temperature in Celsius.
Humidity Measurement:
Humidity range: 20 to 80% RH (Relative Humidity).
Humidity accuracy: ±5% RH.

4. SOFTWARE

MIT App Inventor: MIT App Inventor is a powerful, web-based application development environment that allows users to create mobile applications for Android devices. It was originally developed by Google and later transferred to the Massachusetts Institute of Technology (MIT), where it continues to be maintained and enhanced. MIT App Inventor is designed to be accessible to beginners, educators, and those with little to no programming experience, making it a popular tool for creating apps without writing complex code.

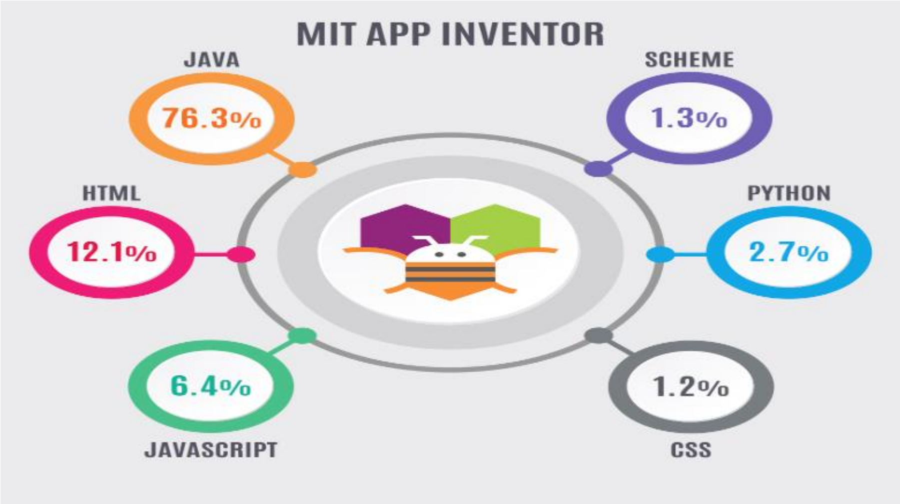

FIGURE 6. MIT App Inventor

Key Features of MIT App Inventor:

Visual Programming Interface:

Drag-and-Drop Blocks: App Inventor uses a blocks-based interface, where you visually design the app by dragging and connecting blocks, instead of writing traditional lines of code.

Easy to Use: Users can focus on the logic of their app without worrying about complex programming syntax.

Real-Time App Testing:

Live Testing with Your Phone: Once you've designed your app, you can instantly test it on your Android phone using the MIT AI2 Companion App, which allows for live preview and testing during development.

Design and Functionality:

Designer Interface: This is where you lay out the components of your app, such as buttons, images, text boxes, and sensors.

Blocks Editor: This is where the logic and functionality of the app are created by connecting visual blocks to define behaviors, actions, and responses.

Arduino IDE: Arduino IDE permits the user to perform real-time operations by writing and uploading the codes in ceitis open-source that makes easy to use. It is available for a wide range of operating systems such as MAC, Windows, and Linux. It accepts Java Platform as well. It is gifted with many in built functions that help in debugging and to compile in the environment. It also holds others alient features as we can easily share any details with others. We are not restricted in changing the schematics when required. It also has guidelines for installation for beginners.

Low Power Consumption

Highly Scalable for IoT Networks

Processing: Processing is easy to use since it is open-source. It helps building the graphical interpretation of the result. It mainly designed for the student community who were not programmers, to create a visual context. It uses java along with the computer program for graphs the way for Simplified execution and compilation.It additionally permits users to form their categories at intervals the Applet sketch. This enables complicated knowledge sorts that will embraceany variety of arguments.

5. WORKING

This setup could function as a Lithium-ion Battery Monitoring System using IoT, focusing on the components present their potential roles:

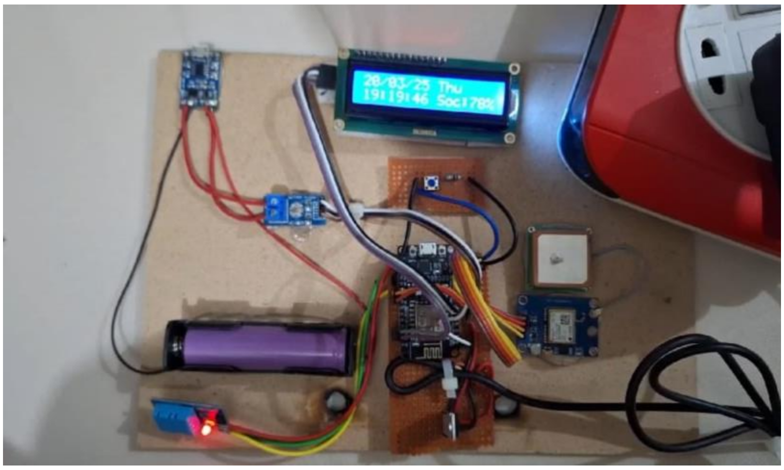

FIGURE 7. Hardware design of a battery monitoring system for lithium-ion batteries using IOT

Components and their Functions (with Updates): The system consists of several key components, each serving a specific function. The ESP8266 Wi-Fi Module acts as the microcontroller, responsible for handling Wi-Fi connectivity and processing tasks, enabling communication with other devices or remote systems. The LCD Display shows essential data such as "20/03/25 Thu 19:11:46 Soc178," indicating the current date, time, and potentially a sensor reading or status code (e.g., "Soc178"). The system likely uses a Real-Time Clock (RTC) Module to provide accurate timekeeping, ensuring that the displayed date and time are correct. The GPS Module allows the system to determine its geographic location, including latitude, longitude, and altitude, by receiving signals from satellites. A Temperature/Humidity Sensor (identified by a blue module with a red LED) measures the environmental conditions, providing real-time data on temperature and humidity levels. The system is powered by a Battery, which provides portable power to the components. A Voltage Regulator ensures that the components receive a stable voltage, preventing damage or malfunction due to power fluctuations. The Wiring and Breadboard physically connect all the components, allowing them to communicate and work together.

In terms of functionality, the system likely operates as follows: The GPS Module determines the device’s location by acquiring satellite signals for latitude, longitude, and altitude. Simultaneously, the Temperature/Humidity Sensor monitors the environmental conditions and gathers real-time data. This information is displayed on the LCD, which shows the current date, time, and status, including potential sensor readings like "Soc178." The ESP8266 Wi-Fi Module transmits the gathered data, enabling remote access or integration with cloud systems for analysis or monitoring. The Battery powers the system, with the Voltage Regulator ensuring stable power delivery to all components. Together, these elements create a system that monitors environmental and location-based data, displays critical information, and communicates remotely, all while ensuring reliable performance.

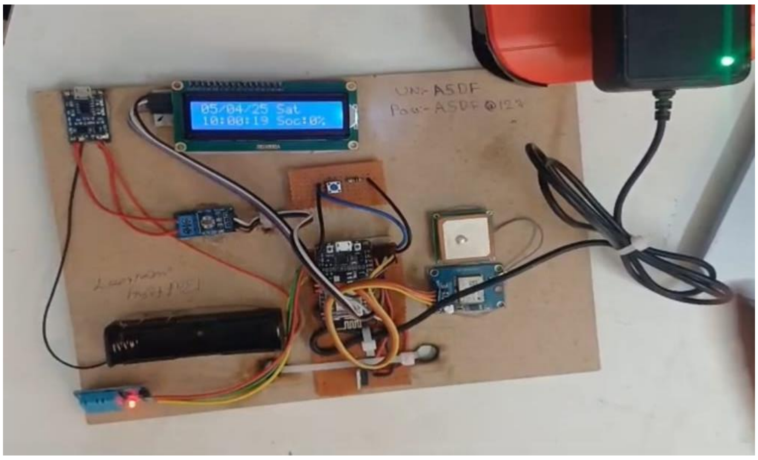

FIGURE 8. Working of Battery Monitoring System for Li-Ion Batteries

The system operates in a well-coordinated manner with various components working together to achieve its intended functions. The RTC module ensures accurate timekeeping by continuously tracking the current date and time. The ESP8266 microcontroller serves as the central unit, processing the data it receives from the GPS, temperature/humidity sensor, and RTC module. It then formats this information, including the date, time, geographical location, temperature, and humidity, and displays it on the LCD for easy viewing. Furthermore, the ESP8266 has Wi-Fi capabilities that allow it to transmit this data to a remote server or cloud platform, enabling real-time monitoring and data logging from any location.

This system has a wide range of potential applications. Asset Tracking is one of the key uses, where the system can be employed to track the location of valuable assets, such as vehicles or packages, ensuring they are always monitored. Environmental Monitoring is another important application, especially for remote locations, where the system can monitor temperature, humidity, and location, transmitting this data wirelessly for further analysis or alerts. The system can also be used for Personal Tracking, enhancing safety by providing real-time location data in case of emergencies, such as for hikers or outdoor workers. Lastly, the system can support Geocaching or Navigation Projects, where the GPS and display features help with navigation or location-based activities, offering an interactive and engaging experience for users.

Key Observations:

- **Integration:** The components are well-integrated, suggesting a more advanced stage of development.
- **Data Focus:** The LCD clearly displays data, indicating a data-centric application.
- **Portability:** The battery highlights the system's intended portability.

6. RESULTS

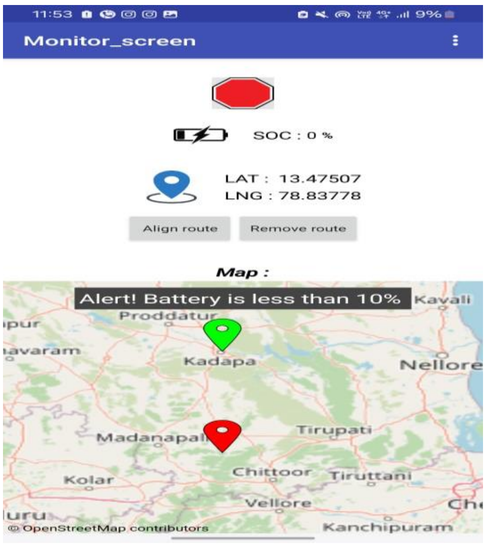

FIGURE 9. Low battery percentage alert notification **FIGURE** 10. Nearby location of charging station& vehicle.

FIGURE 11. Temperature and Humidity startus of the Battery

FIGURE 12. LI-ION Battery Electrical vehicle

7. CONCLUSION

Battery Monitoring System for Lithium-Ion Batteries Using IoT

The IoT-based Battery Monitoring System for Lithium-Ion Batteries presents an innovative solution to the challenges commonly faced in battery management, especially for applications in electric vehicles (EVs) and portable devices. By integrating real-time monitoring, user notifications, and GPS-based charging station guidance, the system offers significant advantages in terms of safety, efficiency, and user convenience.

Key Achievements:

- **User Convenience**: The system enables users to easily monitor their battery's health and status through a mobile app, providing real-time updates and alerts about battery levels and other critical parameters.
- **Safety**: By incorporating temperature and voltage monitoring, the system ensures that the battery operates within safe limits, helping to prevent overheating, overcharging, or deep discharges, all of which can contribute to battery degradation or failure.
- **Operational Efficiency**: The ability to track the battery's condition and offer guidance to nearby charging stations enhances the overall user experience, especially for EVs, where battery management is critical for efficient operation.

This system can be a game-changer for industries relying on lithium-ion batteries, enabling smarter, safer, and more efficient battery management solutions. As IoT technology continues to evolve, the integration of advanced sensors, offline capabilities, and power optimization techniques will further extend applicability of this system, facilitating its adoption in a wide range of battery-powered applications.

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