© May 2025 | IJIRT | Volume 11 Issue 12 | ISSN: 2349-6002

Monitoring The EV Battery Management System by Using IOT

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***Abstract—*Electric vehicles (EVs) represent a promising solution for reducing greenhouse gas emissions and dependence on fossil fuels. However, effective monitoring of critical parameters such as battery voltage, current, and temperature is essential for ensuring the safety and performance of EV systems and Using UART for battery indication. In this project, we propose the development of an Electric Vehicle Monitoring System (EVMS) using ESP32 microcontroller interfaced with voltage, current, and temperature sensors. The system integrates with Thing Speak, an Internet of Things (IoT) platform, for real-time data storage and monitoring. The ESP32 continuously collects sensor data and transmits it to Thing Speak servers over the internet. Moreover, the EVMS incorporates temperature control mechanisms by activating a fan and sounding a buzzer in case of high battery temperature, thus preventing potential overheating and damage. The proposed system offers an affordable and scalable solution for monitoring electric vehicle parameters, contributing to enhanced safety, reliability, and performance of EVs.**

***Index terms—* Electric vehicle monitoring, ESP32, ThingSpeak, IoT, voltage sensor, current sensor, temperature sensor, Blynk, real-time data.**

I. INTRODUCTION

The global shift toward electric vehicles (EVs) presents significant opportunities to reduce environmental pollution and dependence on fossil fuels. EVs are a cornerstone in the transition to sustainable transportation systems, offering benefits such as lower carbon emissions, reduced noise pollution, and decreased operating costs. However, ensuring the safety, performance, and longevity of electric vehicles heavily relies on the efficient monitoring of their internal systems, especially the battery. The battery is the most critical and sensitive component in an EV. Parameters such as voltage, current, and temperature must be continuously monitored to prevent issues such as overheating, overcharging, deep discharge, and thermal runaway, all of which can lead to reduced battery life or hazardous failures.

While commercial Battery Management Systems (BMS) exist, many are expensive, proprietary, and not user-friendly. These limitations hinder their application across diverse EV models, especially in budget or custom-built electric vehicles. Moreover, many of these systems lack real-time data accessibility and remote monitoring capabilities, which are essential for diagnostics, predictive maintenance, and fleet management. This paper presents a cost-effective, scalable, and IoT-enabled Electric Vehicle Monitoring System (EVMS) using the ESP32 microcontroller, integrated with voltage, current, and temperature sensors. The system utilizes ThingSpeak for real-time cloud-based monitoring and Blynk for mobile alerts and control. Additionally, it includes a cooling system and buzzer, which are triggered automatically to prevent thermal failures.

Through the implementation of this smart monitoring solution, we aim to improve the safety, reliability, and efficiency of EVs while making advanced diagnostics and remote control more accessible to both manufacturers and users.

II. OBJECTIVE

The primary objective of this project is to design and implement a smart, cost-effective Electric Vehicle Monitoring System (EVMS) that ensures real-time monitoring of key battery parameters such as voltage, current, and temperature. By utilizing the ESP32 microcontroller along with integrated sensors, the system aims to provide continuous data collection and wireless transmission to IoT platforms. The EVMS is developed to work with the ThingSpeak cloud service for data logging and visualization, while also incorporating the Blynk mobile application for remote access, control, and alert notifications. Additionally, the system includes built-in safety mechanisms such as a cooling fan and buzzer that activate when battery temperature exceeds safe thresholds. This solution is intended to be scalable, user-friendly, and suitable for a wide range of electric vehicle platforms, thereby contributing to improved battery performance, operational safety, and preventive maintenance.

III. EXISTING SYSTEM

The existing systems for monitoring electric vehicles often entail various challenges and limitations. Many commercial solutions are tailored for specific vehicle models, leading to limited compatibility and scalability across different EV platforms. Additionally, these systems typically rely on proprietary hardware and software, resulting in high costs and limited accessibility for consumers and manufacturers alike. Moreover, the lack of real-time monitoring capabilities and remote access further impedes proactive maintenance and timely intervention. Without comprehensive monitoring of critical parameters such as battery voltage, current, and temperature, electric vehicles are susceptible to various risks, including overheating, battery degradation, and safety hazards. As a result, there is a clear need for an innovative and accessible Electric Vehicle Monitoring System (EVMS) that can address these challenges effectively while enhancing the safety, reliability, and performance of electric vehicles.

IV. PROPOSED SYSTEM

The proposed Electric Vehicle Monitoring System (EVMS) presents an innovative solution aimed at addressing the limitations of existing monitoring systems while enhancing the safety, reliability, and performance of electric vehicles.
This system integrates an ESP32 microcontroller with voltage, current, and temperature sensors to monitor critical parameters of electric vehicle batteries. By leveraging the capabilities of the ThingSpeak IoT platform, real-time data transmission and remote monitoring are enabled, allowing users to access and analyze vehicle data from anywhere with internet connectivity. In addition to passive monitoring, the EVMS incorporates proactive temperature control mechanisms to mitigate risks associated with overheating. When battery temperature exceeds predefined thresholds, the system automatically activates a cooling fan and sounds a buzzer to alert users and prevent potential damage. This functionality ensures timely intervention and enhances the overall safety of electric vehicles. Moreover, the proposed system is designed to be cost-effective, scalable, and user-friendly, making it accessible to a wide range of consumers and manufacturers. Through the implementation of the EVMS, we aim to contribute to the advancement of sustainable transportation by promoting the adoption of electric vehicles and improving their operational efficiency and reliability.

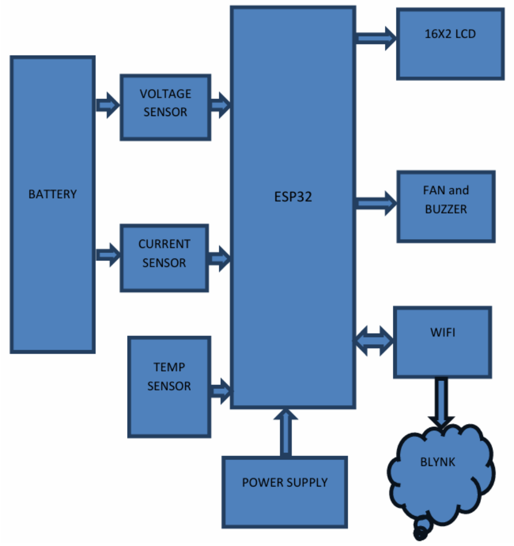

Fig.1 BLOCK DIAGRAM

ESP32 Microcontroller:
The ESP32 serves as the central processing unit of the system. It is powered by a stable power supply, typically 5V DC. The ESP32 reads analog sensor data, controls output devices, and manages communication with external modules.

Voltage Sensor Interface:
The voltage sensor is connected to one of the analog input pins (e.g., A0) of the ESP32. It measures the voltage of the electric vehicle battery. The voltage sensor typically outputs a voltage proportional to the battery voltage, which is read by the ESP32's analog-to-digital converter (ADC). Ensure proper scaling and calibration of the sensor output to obtain accurate voltage readings.

Current Sensor Interface:
The current sensor is connected to another analog input pin (e.g., A1) of the ESP32. It measures the current flowing through the electric vehicle system. The current sensor may use a shunt resistor or hall-effect sensor to measure current, providing an analog voltage output proportional to the current. This

voltage is read by the ESP32 and converted into current measurements.

Temperature Sensor Interface:
The temperature sensor is connected to a different analog input pin (e.g., A2) of the ESP32. It measures the temperature of the electric vehicle battery. The temperature sensor may use thermistors, IC temperature sensors, or other types of temperature-sensing devices. The analog voltage output from the temperature sensor is read by the ESP32 and converted into temperature readings using appropriate calibration and scaling.

Cooling Fan and Buzzer Control:
The cooling fan and buzzer are connected to separate digital output pins of the ESP32 (e.g., digital pins 8 and 9). When the temperature reading exceeds predefined thresholds, the ESP32 activates the cooling fan by setting its corresponding pin to HIGH. Simultaneously, it activates the buzzer by setting its pin to HIGH, alerting users about the overheating condition.

Wi-Fi Module Interface:
If Wi-Fi connectivity for remote monitoring is desired, an additional Wi-Fi module (e.g., ESP8266 or ESP32) can be interfaced with the ESP32.
The Wi-Fi module communicates with the ESP32 via serial communication and facilitates internet connectivity for data transmission. Data from the sensors can be sent to the ThingSpeak IoT platform or other cloud services using HTTP requests or MQTT protocols.

Power Supply Management:
A stable power supply is crucial for the proper operation of the EVMS.
Voltage regulators, such as LM7805, may be used to regulate the input voltage to 5V for powering the ESP32 and other components. Ensure adequate current capacity to power all components reliably.

SYSTEM ARCHITECTURE

Battery
The battery is the primary power source for the electric vehicle. It supplies electrical energy to the motor and other components. In this system, it is also the source under observation. Its voltage and current are continuously monitored to assess battery health, usage patterns, and to prevent critical failures like deep discharge or overload.

Voltage Sensor
The voltage sensor is responsible for measuring the output voltage of the battery. It steps down the voltage through a voltage divider so it can be safely read by the ESP32's analog input pin. This data helps track the state of charge and identify overvoltage or undervoltage conditions in the system.

Current Sensor
The current sensor (typically ACS712) detects the amount of current flowing from the battery to the load. It sends an analog signal proportional to the current level to the ESP32. Monitoring current is important for identifying unusual power consumption, faults, or short circuits within the electric vehicle's circuitry.

Temperature Sensor
The temperature sensor, such as a DHT11, monitors the ambient or battery temperature. It provides real-time data to the ESP32, enabling the system to react if the battery becomes too hot. Temperature is a key safety factor in EVs, and this sensor helps prevent thermal runaway or component degradation.

ESP32
The ESP32 is the main controller of the system. It receives input from all the sensors, processes the data, displays results on the LCD, and takes decisions such as activating the fan or buzzer if safety thresholds are exceeded. It also handles Wi-Fi communication, sending data to cloud platforms like Blynk for remote access and monitoring.

16x2 LCD
The 16x2 LCD is a local display module that shows real-time values of voltage, current, and temperature. It allows users to view system parameters directly on the hardware without needing to open a mobile app or connect to the internet.

Fan and Buzzer
These components form the alert and cooling mechanism. When the ESP32 detects an abnormal rise in temperature, it activates the fan to cool down the system and triggers the buzzer to alert users. This setup provides both visual and audible indicators of critical conditions.

Wi-Fi Module
Although the ESP32 has built-in Wi-Fi, this block represents the communication interface that connects the microcontroller to the internet. Through Wi-Fi, the ESP32 transmits sensor data to IoT platforms and enables real-time monitoring from anywhere.

Remote Monitoring (Blynk App on Smartphone)
Blynk is the IoT cloud platform used to remotely monitor and control the EVMS. It provides a mobile application interface where users can view live sensor data, receive alerts, and interact with the system in real time. It enhances accessibility and usability beyond the physical system.

Power Supply
The power supply unit ensures that all electronic components, including the ESP32 and sensors, receive a stable and regulated voltage, typically 5V or 3.3V. It converts higher battery voltages to levels suitable for microcontroller operation, ensuring safe and consistent performance.

Modulation Technique & Principle

- Technique: Orthogonal Frequency Division Multiplexing (OFDM)
- Modulation Types within OFDM: BPSK, QPSK, 16-QAM, 64-QAM (adaptive based on signal quality)
- Modulate the amplitude, phase, or frequency of a carrier wave using digital signals.
- OFDM splits the data stream into multiple smaller sub-streams, modulates them separately, and transmits them over closely spaced carriers to improve bandwidth efficiency and reduce interference.

ADVANTAGES
The Electric Vehicle Monitoring System (EVMS) offers real-time monitoring of battery voltage, current, and temperature, enabling proactive maintenance and timely interventions. By integrating with the ThingSpeak IoT platform, users can remotely access and analyze vehicle data from any location with internet access. The system features intelligent temperature control to prevent overheating, enhancing EV safety and reliability. Built with affordable, readily available components and open-source software, EVMS is a cost-effective alternative to proprietary systems. Its scalable and user-friendly design allows easy deployment across various electric vehicle fleets for both consumers and manufacturers.

DEVICE AND IT’S USE

Electric Vehicle Health Monitoring
The EVMS system enables real-time monitoring of voltage, current, and temperature in electric vehicle batteries, helping prevent failures and enhancing operational safety.

Overheat Detection and Cooling
Using a DHT11 temperature sensor, DC fan, and buzzer, the system detects overheating and activates cooling mechanisms with alert notifications to avoid battery damage.

Remote Vehicle Diagnostics
Integration with the ThingSpeak IoT platform allows users and fleet managers to monitor EV health data remotely, ensuring timely maintenance and reducing breakdown risks.

Cost-Effective EV Management
By utilizing affordable sensors and open-source technology (ESP32, Arduino IDE), the system reduces the need for expensive commercial EV diagnostic tools.

Scalable Fleet Monitoring
The EVMS can be implemented across multiple vehicles in commercial or public transport fleets, offering centralized performance tracking and reliability improvements.

SAFETY INCIDENT ANALYSIS REPORT
This report analyzes battery-related risk trends in electric vehicles from 2010 to 2025. In 2010, there were approximately 95 incidents related to battery overheating, voltage imbalance, or power failure, rising to 147 incidents in 2025. The increase is attributed to higher EV adoption and older battery packs in circulation. Specifically, user-reported incidents rose from 28 in 2010 to 63 in 2025, while technician-detected or system-diagnosed issues increased from 67 to 84. The need for real-time monitoring systems like EVMS becomes clear, as such tools enable early fault detection, reducing the chances of catastrophic failures and enhancing the safety and reliability of EV usage across all sectors.

V. CONCLUSION

In conclusion, the development and testing of the Electric Vehicle Monitoring System (EVMS) have showcased its effectiveness in addressing the limitations of existing monitoring solutions while significantly enhancing the safety, reliability, and performance of electric vehicles. The EVMS's real-time monitoring capabilities, remote accessibility through the ThingSpeak IoT platform, and proactive temperature control mechanisms represent substantial advancements in electric vehicle technology. By providing timely alerts and interventions in response to critical parameters, the EVMS not only safeguards the integrity of battery systems but also contributes to overall vehicle safety.

VI. RESULT IMAGES

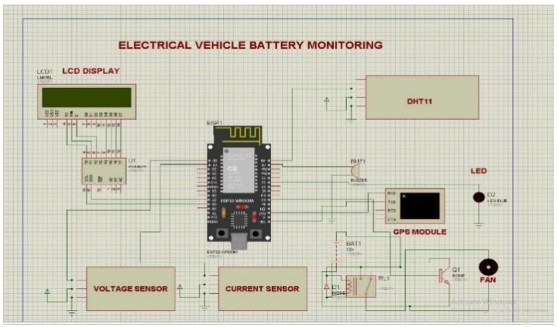

Fig.2 CIRCUIT DIAGRAM

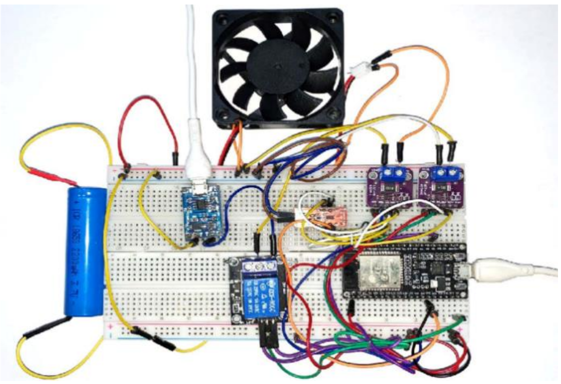

Fig.3 HARDWARE SETUP

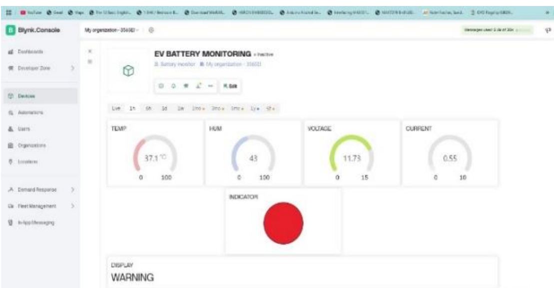

Fig.4 SYSTEM OUTPUT

Fig.5 REALTIME TESTING

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