

ELECTRIC VEHICLE QUALITY ORIENTED MONITORING AND CONTROLLING SYSTEM USING IoT

Y. Amreen Banu¹, V. Jaya Jothi², A. Shareen Banu³, ^{1,2,3}Students,

Dr.N.Thenmoezhi⁴, K. Padmapriya⁵

⁴Assistant Professor(SG), ⁵Assistant Professor

Electronics and Communication Engineering Department,

AAA College of Engineering and Technology, Sivakasi, Tamil Nadu, India

Abstract- Electric vehicles require continuous supervision of critical parameters to ensure operational safety, reliability, and long service life. This paper presents a quality-oriented electric vehicle monitoring and controlling system based on Internet of Things (IoT) technology. The proposed system continuously monitors battery voltage, load current, and temperature using embedded sensors interfaced with a microcontroller. Real-time data acquisition enables early detection of abnormal conditions such as over-current, under-voltage, and overheating. When predefined threshold values are exceeded, the system initiates protective control actions and generates audio alerts to inform the user immediately. The monitored data can also be visualized remotely through IoT communication, enabling effective supervision and fault diagnosis. Experimental results demonstrate that the proposed system enhances vehicle safety, improves battery and motor protection, and supports quality-oriented operation of electric vehicles with low implementation cost.

Keywords: Electric Vehicle, Internet of Things, Battery Monitoring, Quality-Oriented Control, Sensors, Embedded System

I. INTRODUCTION

Electric vehicles have emerged as a promising solution to the growing concerns related to environmental pollution, fuel depletion, and rising energy costs. By replacing conventional internal combustion engines with electric powertrains, electric vehicles significantly reduce greenhouse gas emissions and improve energy efficiency. However, the increasing adoption of electric vehicles also introduces new technical challenges related to safety, reliability, and performance. Unlike traditional vehicles, electric vehicles depend heavily on batteries, electric motors, and power electronic components, all of which are sensitive to operating conditions.

The battery system plays a critical role in determining the overall performance and lifespan of an electric vehicle. Parameters such as battery voltage, current flow, and temperature directly affect charging efficiency, driving

range, and safety. Similarly, abnormal current draw or excessive temperature rise in the motor can lead to performance degradation, component damage, or even hazardous conditions. Therefore, continuous monitoring of these parameters is essential to ensure stable and safe vehicle operation.

In many existing electric vehicle systems, monitoring is limited to basic indicators or periodic manual inspection. Such methods do not provide real-time awareness of internal operating conditions and often fail to identify faults at an early stage. As a result, issues such as battery over-discharge, overheating, or excessive current consumption may remain unnoticed until serious damage occurs. This limitation increases maintenance costs, reduces component lifespan, and compromises vehicle reliability.

Recent advancements in the Internet of Things (IoT) have opened new opportunities for intelligent monitoring and control in electric vehicles. IoT enables the integration of sensors, microcontrollers, and communication technologies to collect and process data continuously. Through IoT-based systems, vehicle parameters can be monitored in real time, abnormal conditions can be detected instantly, and alerts can be generated without human intervention. This approach enhances system responsiveness and supports informed decision-making for maintenance and control.

In this context, the objective of this work is to develop a quality-oriented electric vehicle monitoring and controlling system using IoT principles. The proposed system focuses on continuously observing key parameters such as battery voltage, load current, and operating temperature. The collected sensor data is processed by a microcontroller and compared with predefined safety thresholds. When abnormal conditions are detected, the system generates immediate alerts and initiates protective control actions to prevent damage to vehicle components.

By providing real-time monitoring and early fault detection, the proposed system improves operational safety and reliability. Additionally, the system supports better energy management by preventing deep battery discharge and thermal stress. The overall design is simple, cost-effective,

and suitable for practical implementation in electric vehicles. Through this approach, the system contributes to improving vehicle quality, extending component lifespan, and supporting the development of safer and more efficient electric transportation systems.

II. RELATED WORK

Many researchers have worked on improving monitoring systems for electric vehicles, especially focusing on battery safety. Since the battery is the primary energy source of an EV, its voltage, current, and temperature need continuous observation. Earlier systems mainly concentrated on protecting the battery from overcharging and deep discharge. These designs used simple voltage cut-off techniques to stop operation when limits were crossed.

Later, researchers started integrating temperature sensors to prevent overheating issues. It was observed that continuous rise in temperature reduces battery efficiency and long-term performance. Some systems provided alert indications when the temperature exceeded a predefined value. However, these solutions were mostly standalone and did not combine multiple parameters in a single framework.

With the development of IoT technology, remote monitoring became possible. Several studies proposed transmitting battery data to cloud platforms for analysis and visualization. Users could check the vehicle status using web or mobile applications. Even though this improved accessibility, many systems did not include immediate in-vehicle control mechanisms when abnormal conditions occurred.

Embedded microcontroller-based monitoring has also been implemented in electric drive applications. These systems were capable of detecting abnormal voltage or current levels. However, integration with cloud storage and real-time remote supervision was not always considered.

From reviewing the existing works, it is clear that most approaches focus on either monitoring, communication, or protection separately. A combined system that performs multi-parameter sensing, instant fault detection, local alert generation, and IoT-based remote monitoring together is still limited. Therefore, this project aims to address that gap by developing an integrated monitoring and control framework for electric vehicles.

III. PROPOSED METHODOLOGY

In this project, a practical monitoring and control system is developed to observe important operating conditions of an

electric vehicle in real time. The main idea behind the proposed method is to continuously measure key parameters such as battery voltage, current, and temperature, and to take necessary action if any abnormal condition occurs.

To achieve this, suitable sensors are connected to the battery and load section of the vehicle setup. These sensors measure real-time values during operation and send the signals to the microcontroller. In our prototype, a microcontroller board is used as the central processing unit to handle data collection and decision-making.

Inside the controller, the measured values are compared with predefined safe limits. These limits are selected based on normal operating conditions of the battery system. If the temperature increases beyond the set threshold, the system identifies it as an overheating condition and generates a warning alert. Similarly, when the battery voltage drops below the minimum level, a low-voltage indication is triggered to prevent deep discharge.

Apart from local monitoring, the system is also connected to an IoT communication module. This allows the measured data to be transmitted to a cloud platform so that the user can monitor vehicle status remotely. The combination of sensing, processing, and communication ensures that faults can be detected at an early stage.

Overall, the proposed methodology focuses on providing a simple, cost-effective, and reliable monitoring framework. By integrating real-time sensing with automatic alert generation and remote supervision, the system helps in improving safety and maintaining stable vehicle performance.

Algorithm for System Operation

Step 1: Initialize the controller and connected sensors.

Step 2: Acquire voltage, current, and temperature readings.

Step 3: Convert analog signals into digital values.

Step 4: Compare measured values with predefined safety limits.

Step 5: • If voltage falls below threshold → Generate low voltage alert.

- If temperature exceeds 50°C → Activate overheat warning.
- If overcurrent is detected → Enable motor protection.

Step 6: Display real-time readings on LCD.

Step 7: Activate audio alert.

Step 8: Repeat the process continuously.

IV. SYSTEM ARCHITECTURE

The working arrangement of the developed monitoring system is given in Fig. 1. The setup is kept simple so that each section performs a specific role without unnecessary complexity.

In the initial stage, the battery output is connected to voltage and current sensing circuits. These sensors continuously observe the electrical behavior of the system while the vehicle is running. Instead of depending on manual checking, the readings are taken automatically at regular time intervals. A separate regulated supply is used to power the controller board and supporting modules to avoid instability due to voltage fluctuation.

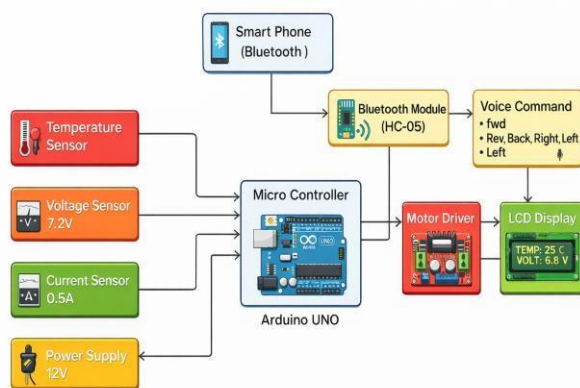


Fig. 1. Block Diagram of the Proposed Electric Vehicle Monitoring System

All measured values are transferred to the microcontroller board. In this prototype, Arduino UNO is selected because it is easy to program and suitable for real-time data acquisition. The controller reads the analog values from the sensors, converts them into digital form, and compares them with the reference limits that were defined during system design.

Whenever the voltage level goes below the normal operating range or the current crosses the safe limit, the controller reacts immediately. A control signal is sent to the motor driver section, which manages the load operation. Depending on the condition, the system can either restrict the operation or temporarily stop it to prevent further damage. Along with this control action, the present values are shown on the LCD display so that the user can directly see the system condition.

By combining sensing, monitoring, and protection into one coordinated unit, the proposed system reduces the chances of battery stress and electrical faults. The design focuses more on practical implementation rather than theoretical complexity, making it suitable for real-time electric vehicle applications.

V. SYSTEM IMPLEMENTATION

The proposed electric vehicle monitoring system was developed as a working hardware prototype to validate the design concept. The entire setup was assembled using commonly available electronic modules and interfaced with an Arduino UNO microcontroller, which serves as the central processing unit of the system.

A. Hardware Implementation

The Arduino UNO board was selected due to its simplicity, reliability, and sufficient input-output capabilities. The voltage sensor module was connected across the battery terminals to continuously measure the battery output voltage. A current sensor was connected in series with the load to monitor the real-time current flow during system operation.

To observe thermal behavior, a temperature sensor was placed near the battery surface so that any rise in temperature could be detected at an early stage.

All sensor outputs were interfaced with the analog input pins of the Arduino. The microcontroller reads these analog values and internally converts them into digital form using its built-in ADC. Proper grounding and regulated power supply were ensured to maintain stable sensor readings and avoid noise disturbances.

A motor driver module was connected to the digital output pins of the controller. This module controls the load operation based on signals generated by the microcontroller. During abnormal conditions such as overcurrent or low voltage, the driver restricts or disconnects the load to prevent further damage.

For user interaction, a 16×2 LCD display was integrated into the system. It shows real-time voltage, current, and temperature values. In case of fault detection, warning messages are displayed clearly on the screen.

Additionally, a DFPlayer Mini audio module was incorporated to generate voice alerts during critical conditions. This feature improves user awareness by providing both visual and audio indications.

B. Software Implementation

The control program was developed using the Arduino IDE platform. The logic described in the proposed methodology was implemented in the form of a continuous monitoring loop.

At the beginning of the program, all sensors and output modules are initialized. Predefined safety thresholds for voltage, current, and temperature were stored within the program based on safe operating limits.

Inside the main loop, the controller performs the following actions:

- Reads sensor values at regular intervals
- Converts analog inputs into digital values
- Compares measured values with predefined thresholds
- Identifies abnormal conditions if limits are exceeded

If any unsafe condition is detected, the controller immediately activates the protective mechanism through the motor driver. At the same time, warning messages are displayed on the LCD and audio alerts are triggered using the DFPlayer module. The monitored data is also prepared for transmission to the IoT dashboard for remote observation. The monitoring process continues repeatedly without interruption to ensure real-time protection.

C. Prototype Development

The hardware prototype was assembled carefully on a compact development board by integrating all the required

modules. Each component was connected based on the designed circuit layout, and special attention was given to proper wiring to avoid loose connections. After completing the assembly, the system was powered on and basic functionality checks were performed.

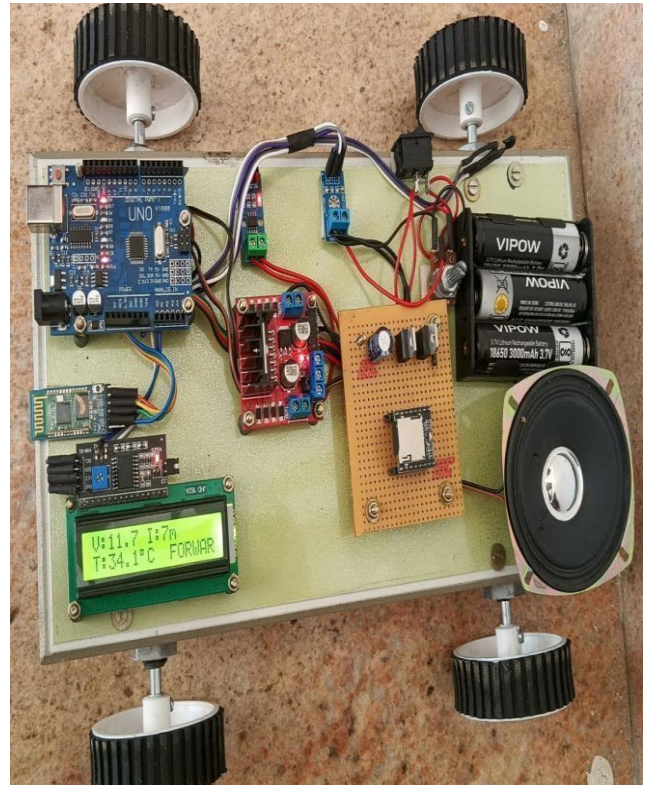


Fig. 2. Experimental Prototype of the Developed EV Monitoring System

During the first few trials, slight variations were noticed in the sensor readings immediately after startup. These variations were mainly due to supply stabilization and environmental interference. To overcome this, a regulated power supply was used and proper grounding was ensured across all modules. After these adjustments, the readings became stable and consistent.

Once stable operation was achieved, the prototype was tested under normal operating conditions. The voltage, current, and temperature values were observed to remain within the predefined safety limits. The LCD displayed real-time data continuously without interruption.

To further validate system performance, fault conditions were intentionally introduced. When the voltage was reduced below the set limit, the system generated a warning message and triggered the protection mechanism. Similarly, during overload and elevated temperature conditions, the controller responded immediately by activating alerts and controlling the load.

These tests confirmed that the developed prototype operates reliably and performs monitoring and protective functions as expected.

VI. RESULT AND DISCUSSION

The developed prototype was tested under different operating conditions to evaluate its monitoring accuracy and protection capability. The system was powered using a 12 V battery source and tested with a controlled load to observe voltage, current, and temperature variations. The readings displayed on the LCD were manually verified using a digital multimeter to ensure measurement reliability.

A. Normal Operating Condition

Initially, the system was tested under standard operating conditions without introducing any fault. The observed values are presented in Table 1.

Table 1. Observed Parameters under Normal Condition

Parameter	Observed Value	Status
Battery Voltage	11.7V	Normal
Load Current	3.3A	Normal
Battery Temperature	34.1°C	Normal

From the recorded values, it can be observed that all parameters remained within their predefined safety limits. The LCD continuously displayed real-time measurements without interruption. No warning messages or audio alerts were triggered during this stage, indicating stable system performance.

B. Threshold Configuration and Functional Response

To ensure reliable protection, safety thresholds were predefined in the controller program.

The configured limits and their respective system actions are shown in Table 2.

Table 2. Configured Threshold Values and System Response

Sensor Module	Monitored Parameter	Threshold Value	System Function
Voltage Sensor	Battery Voltage (Vb)	< 10 V	Low battery detection and recharge alert
Temperature Sensor	Battery Temperature (Tb)	> 50°C	Overheat detection and warning indication
Current Sensor	Load Current (Ib)	> 5 A	Overload detection and alert indication
Bluetooth Module	Control Command	Valid / Invalid	Vehicle movement control
Microcontroller (Arduino)	System Status	Threshold exceeded	Generate alert and display warning

The threshold values were selected based on safe battery operating conditions. Whenever any monitored parameter crossed its defined limit, the microcontroller generated an immediate response. Visual alerts were displayed on the LCD, and an audio warning was activated through the DFPlayer Mini module.

C. Abnormal Condition Testing

To verify fault detection capability, different abnormal scenarios were intentionally created. When the battery voltage was reduced to approximately 8.8 V, the system detected a low-voltage condition and displayed a recharge alert message. The protective mechanism prevented further operation to avoid deep discharge.

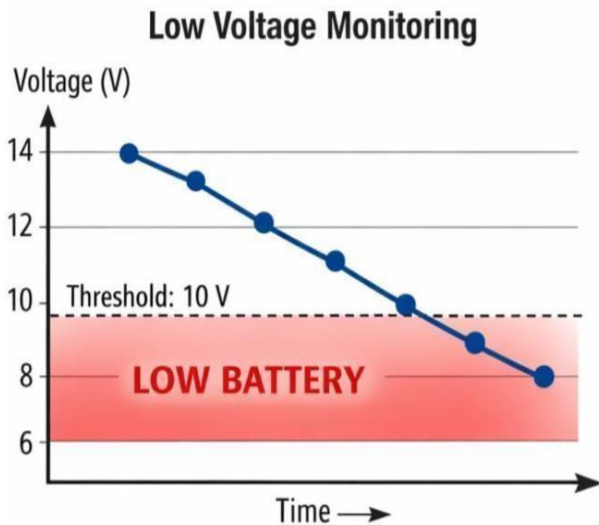


Fig. 3. Voltage Variation under Normal Condition

During thermal testing, the temperature value was gradually increased beyond 50°C . Once the threshold was exceeded, the controller generated an overheat warning and activated the alert system. The response was immediate, indicating proper functioning of the temperature monitoring logic.

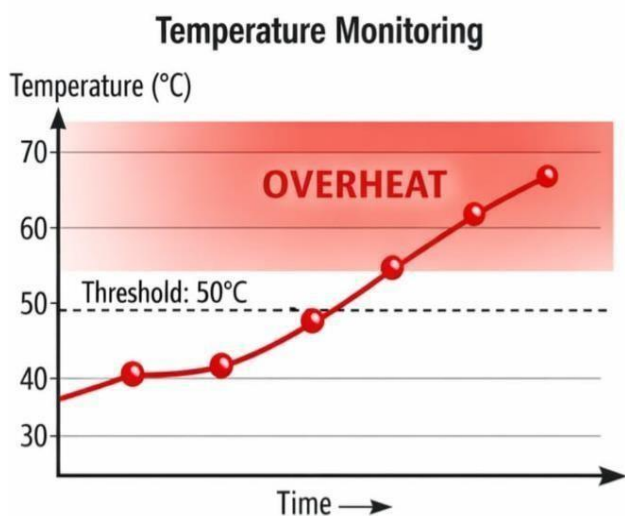


Fig. 4. Temperature Response during Fault Condition

Similarly, when the load current exceeded 5 A, the system identified the overload condition and initiated motor protection. The load was restricted to prevent potential damage.

In all fault scenarios, the system responded without noticeable delay. Both visual and audio alerts were triggered successfully, demonstrating effective coordination between sensing, processing, and control modules.

D. Performance Discussion

The experimental results confirm that the proposed monitoring system operates reliably under both normal and abnormal conditions. Sensor readings remained stable after initial calibration, and the controller accurately identified threshold violations.

The integration of real-time display, audio alerts, and IoT communication enhances user awareness and operational safety. Compared to basic monitoring systems that only display readings, the developed prototype provides active protection by combining detection and control within a single framework.

Overall, the testing results validate the effectiveness of the implemented design and confirm its suitability for electric vehicle safety monitoring applications.

VII. CONCLUSION

This work presented a quality-oriented electric vehicle monitoring and controlling system designed to improve safety, reliability, and overall performance. The proposed system continuously monitors critical parameters such as battery voltage, current, and temperature using embedded sensors interfaced with a microcontroller. By processing sensor data in real time, the system is able to identify abnormal operating conditions and initiate appropriate control actions to protect vehicle components. Experimental results demonstrate that the system effectively prevents issues such as overcurrent, overheating, and excessive battery discharge, thereby enhancing operational safety and extending component lifespan. The simple architecture, low cost, and ease of implementation make the system suitable for practical electric vehicle applications. Overall, the proposed solution provides an efficient and reliable approach for improving the quality and safety of electric vehicle operation.

VIII. FUTURE ENHANCEMENT

The proposed electric vehicle monitoring and controlling system can be further improved by incorporating advanced data analytics and intelligent decision-making capabilities. Future versions of the system may integrate cloud-based platforms to store long-term operational data, enabling detailed performance analysis and historical trend evaluation. By applying artificial intelligence and machine learning techniques, the system can be enhanced to predict battery aging, identify early-stage motor faults, and estimate remaining useful life of critical components.

Such predictive features would support preventive maintenance, reduce unexpected failures, and improve overall vehicle reliability.

In addition, the system can be expanded by integrating modern communication and automation technologies. The inclusion of GPS modules can enable real-time vehicle tracking and location-based alerts, while GSM or 5G connectivity can improve data transmission reliability and coverage. Smart charging features can also be introduced by allowing communication between the vehicle and charging infrastructure to optimize charging time and energy usage. Furthermore, mobile and web-based applications can be developed to provide users with real-time system status, alerts, and performance reports. These enhancements would make the system more intelligent, scalable, and suitable for future smart electric vehicle and intelligent transportation applications.

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