

IOT-Enabled Fire Protection and Charge Monitoring System for Electric Vehicle Battery Management Systems

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ABSTRACT

The safety of lithium-based battery systems is an important concern in electric vehicles (EVs), particularly during charging and abnormal operating conditions. Excessive temperature, inappropriate charging, voltage variations and electrical faults can accelerate battery degradation and may contribute to hazardous thermal events. This paper presents an IoT-enabled fire protection and charge monitoring system intended to improve the operational safety of an EV battery management system (BMS). The proposed system combines battery parameter monitoring, temperature sensing, wireless energy transfer and cloud-based supervision. Battery voltage, temperature and state-of-charge information are continuously observed by the monitoring unit and transmitted to an IoT platform for remote visualization. The Blynk application provides a convenient interface through which the user can observe battery conditions and receive warnings when abnormal conditions occur. A protective response can be initiated when monitored parameters exceed predefined safe limits, including interruption of charging or activation of a cooling/protection mechanism. The prototype also incorporates a regulated low-voltage supply and wireless charging arrangement to demonstrate the integration of charging and monitoring functions. Experimental observations reported in the project indicate that the system can detect temperature variations, monitor charging conditions and provide remote information with stable operation. The proposed approach demonstrates how IoT connectivity can complement conventional BMS functions and provide an additional layer of safety and remote supervision for electric mobility applications.

Keywords— Electric vehicle, Battery Management System, Internet of Things, Blynk, fire protection, battery monitoring, wireless charging, thermal monitoring.

INTRODUCTION

The increasing use of electric vehicles (EVs) has created a need for safe, reliable, and efficient battery management systems. The battery pack is a critical component of an EV, and its operating condition directly influences vehicle performance and battery life. During charging and discharging, parameters such as voltage, temperature, state of charge (SoC), and current must be monitored to avoid abnormal operating conditions. Excessive temperature, overcharging, and deep discharge can reduce battery performance and may lead to serious safety concerns. Therefore, continuous monitoring of battery parameters is essential for improving the reliability and safety of electric vehicles.

A Battery Management System (BMS) performs important functions such as monitoring battery conditions, maintaining safe operating limits, and identifying abnormal charging or discharging conditions. However, remote access to battery information can further improve the effectiveness of battery monitoring. The integration of Internet of Things (IoT) technology enables battery parameters to be transmitted to a cloud platform and accessed through a mobile or web interface. In the proposed system, temperature, voltage, and charging conditions are monitored

continuously, while the IoT platform provides real-time visualization and alerts. The Blynk platform is used to display the monitored information and notify the user when abnormal conditions are detected.

Fire protection is an important requirement in EV battery systems because abnormal temperature rise can indicate a potential hazardous condition. The proposed system combines battery monitoring, temperature sensing, wireless energy transfer, and IoT communication to provide an additional safety layer for EV applications. When parameters such as temperature or charging conditions move beyond the defined safe limits, the controller can generate an alert and initiate a suitable protective response, including interruption of the charging process. Thus, the integration of IoT-based monitoring with BMS functions provides continuous supervision, remote accessibility, and improved safety for EV battery operation.

LITERATURE SURVEY

Nguyen *et al.* [1] investigated the limitations of conventional Battery Management Systems (BMS), particularly their inability to support effective predictive maintenance. Their study emphasized that insufficient long-term observation of battery behavior can result in unexpected failures, increased downtime, and higher maintenance requirements. To overcome these limitations, predictive analytics and machine-learning-based techniques were suggested for monitoring battery health and identifying possible failures in advance. This approach provides a foundation for the present work, in which continuous battery data collection through IoT is considered for identifying abnormal operating patterns and supporting proactive battery maintenance. Chen and Kumar [2] examined charging-related problems in EV battery systems and reported that improper charging, particularly overcharging and undercharging, can adversely affect battery performance and service life. Their work highlights the importance of accurately monitoring electrical parameters during charging. Based on this requirement, the proposed system incorporates real-time monitoring of charging-related voltage and current parameters to improve charging supervision and reduce the possibility of unsuitable charging conditions.

Rahman and Lee [3] focused on the safety implications of undetected electrical faults in EV battery systems. Their study indicated that electrical abnormalities can develop into severe system failures and fire-related hazards when they are not identified at an early stage. The authors therefore emphasized the need for fault-detection mechanisms within BMS architectures. In the proposed system, voltage and current sensing are used to identify abnormal electrical conditions, after which the system can notify the user and initiate a suitable protective action. Smith *et al.* [4] addressed another major EV battery safety issue, namely thermal runaway. Their study emphasized that delayed detection of abnormal temperature rise can increase the severity of overheating events and suggested combining real-time temperature measurement with automated safety responses. The present work follows this approach by continuously monitoring battery temperature and incorporating a protection mechanism capable of generating warnings and initiating corrective action when an unsafe thermal condition is detected.

Alvarez *et al.* [5] investigated the limitations of conventional BMS systems in providing remote access to battery-health information. Their work emphasized that the absence of real-time remote monitoring can delay maintenance and corrective actions, particularly for individual EV users and fleet operators. The authors proposed IoT-based monitoring and control as a means of improving accessibility to battery information. The proposed system extends this concept by integrating IoT communication with battery and thermal monitoring, allowing parameters such as temperature, voltage, and current to be accessed through a mobile or web-based interface. Overall, the reviewed studies address predictive maintenance [1], charging optimization [2], electrical-fault detection [3], thermal-runaway prevention [4], and remote IoT monitoring [5]. The proposed work combines these safety and monitoring aspects into a single prototype, with the objective of providing continuous battery supervision, early abnormal-condition detection, remote notification, and improved fire-protection capability for EV battery systems.

PROBLEM STATEMENT

The increasing adoption of electric vehicles (EVs) has created significant challenges in ensuring the safety, reliability, and efficient operation of their Battery Management Systems (BMS). Conventional BMS solutions may have limited

capabilities for continuous real-time monitoring and early identification of hazardous conditions such as thermal runaway, overcharging, cell imbalance, and electrical faults. These conditions can reduce battery performance and lifespan and may lead to serious safety hazards, including battery fires. In addition, limited remote access to battery-health information can delay timely intervention and maintenance.

Main Objectives

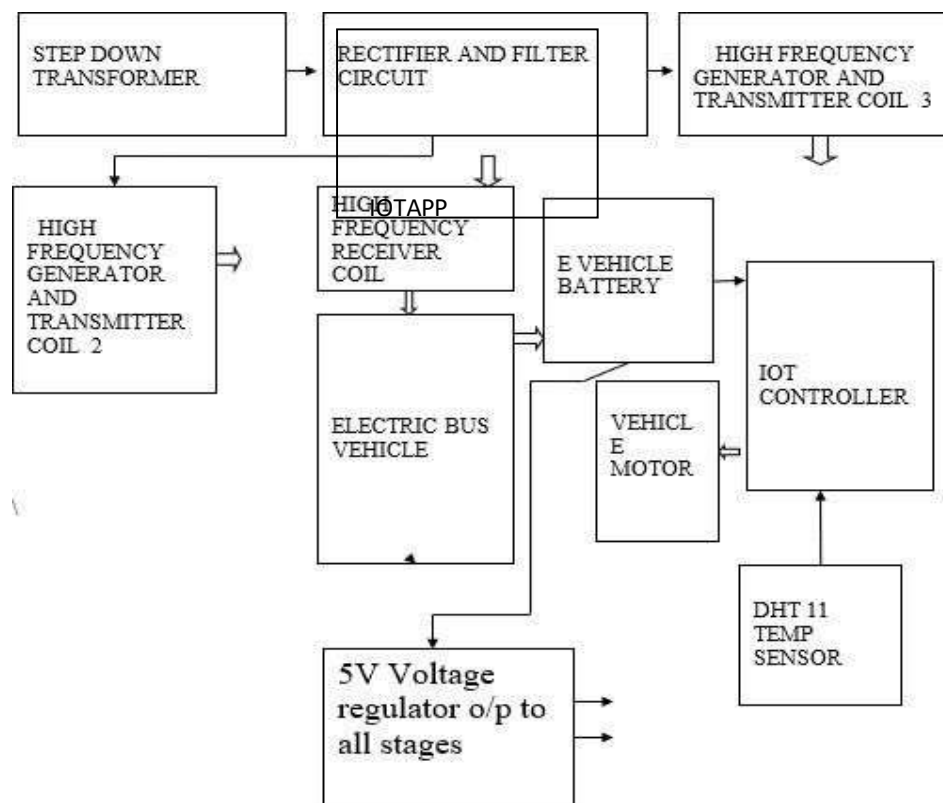
1. To develop an IoT-based system for real-time monitoring of critical EV battery parameters such as temperature, voltage, current, and state of charge.
2. To detect abnormal battery conditions and provide timely fire-protection alerts and appropriate protective action to improve the safety and reliability of EV battery operation.

PROPOSED METHODOLOGY

The proposed system begins with a regulated power supply and charging unit to provide suitable energy to the EV battery. Wireless charging is achieved through electromagnetic induction using transmitter and receiver coils, while the battery is continuously monitored for voltage, current, state of charge (SoC), and temperature. A temperature sensor detects abnormal heating, and the monitoring system identifies conditions such as overcharging, undercharging, and excessive temperature. When unsafe conditions are detected, appropriate protective actions such as stopping the charging process, isolating the faulty section, or activating safety mechanisms are initiated.

An IoT controller collects and processes the sensor data and transmits the information to the **Blynk IoT platform** for real-time remote monitoring. The user can observe battery parameters and receive alerts when abnormal conditions occur. The system also incorporates fire-protection measures to detect overheating and reduce the possibility of thermal hazards. Finally, the complete hardware and software setup is tested under different operating conditions to verify charging performance, monitoring accuracy, IoT communication, and the response of the safety mechanisms.

BLOCK DIAGRAM



OWNER MOBILE UNIT

Figure:1 Block diagram of Fire protection and charge monitoring of BMS in electrical vehicle using IoT

CIRCUIT DIAGRAM

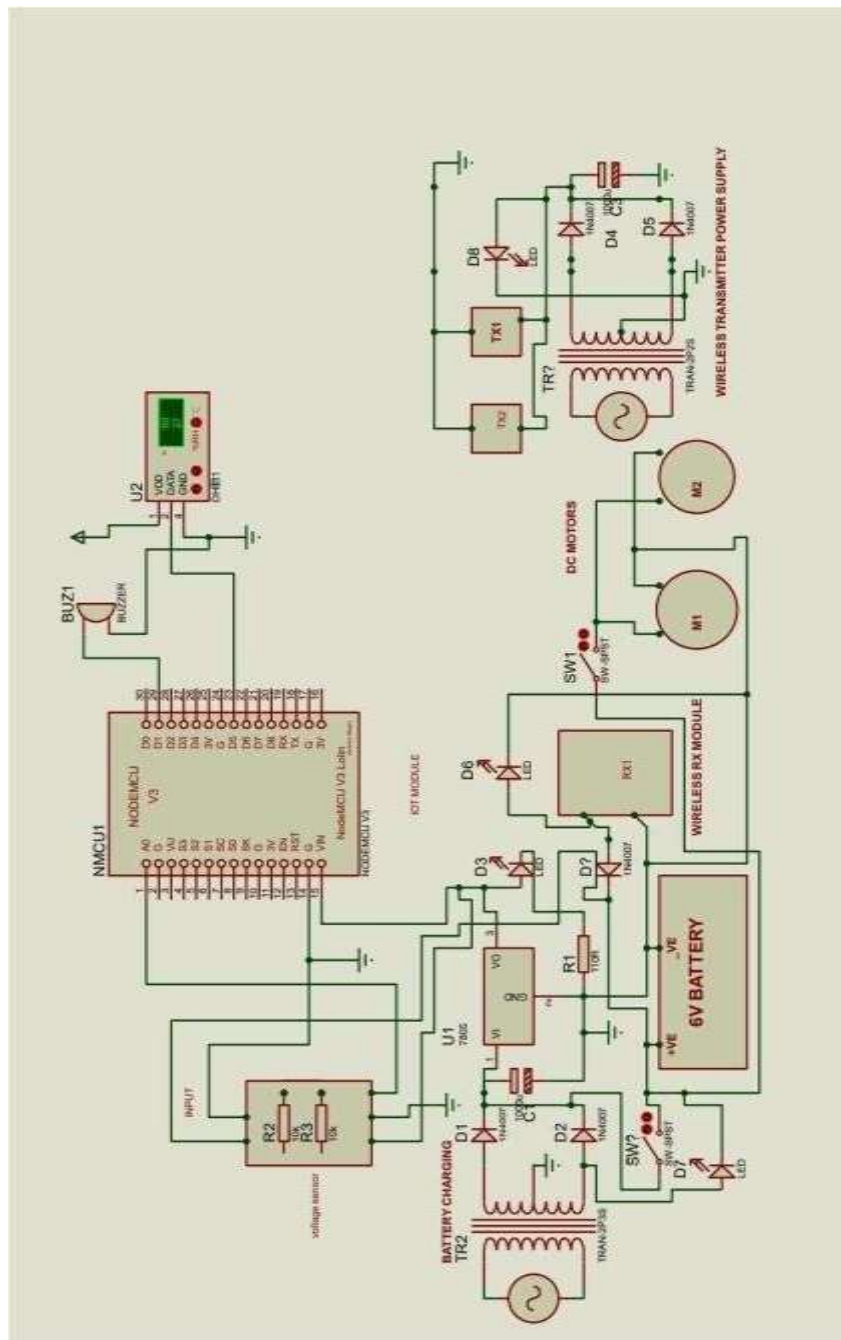


Figure:2 Circuit Diagram of Fire protection and charge monitoring of BMS in electrical vehicle using IOT

RESULTS AND DISCUSSION

The proposed fire protection and charge monitoring system for the Battery Management System (BMS) of electric vehicles (EVs) demonstrated effective performance in improving battery safety and monitoring. The temperature sensing system successfully detected abnormal temperature variations in the battery pack and other critical components, enabling early identification of potential fire hazards. The system also monitored the state of charge (SoC) and voltage levels to ensure that the battery operated within safe limits, thereby reducing the risk of overcharging and undercharging. Through IoT integration, the monitored parameters were transmitted to the cloud, allowing users to access battery status and receive alerts remotely through the Blynk application.

The system exhibited stable and reliable operation under different operating conditions, with continuous monitoring and minimal interruptions. By maintaining appropriate charging conditions and detecting abnormal temperature variations, the system contributed to improved battery efficiency and enhanced battery life. The integration of fire protection, charge monitoring, and IoT-based remote monitoring provides a safer and more reliable approach to EV battery management. The system can be further improved by incorporating advanced smoke and gas sensors and predictive maintenance algorithms for more effective hazard detection and battery condition monitoring.



Figure:3.1 Hardware Setup



Figure:3.2 Hardware Setup

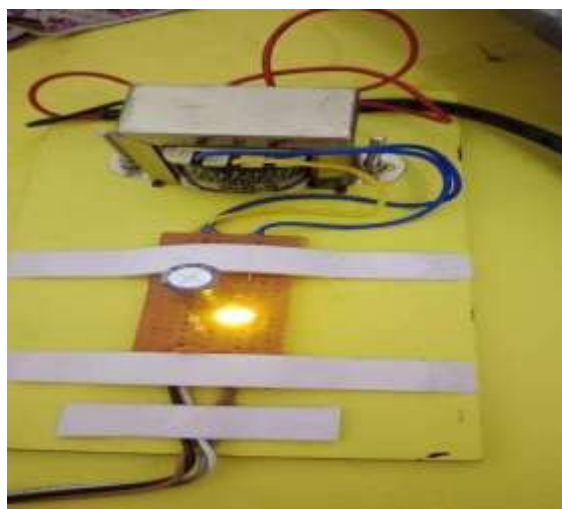


Figure:4.1 road representation



Figure:4.2 Alternate charging indicator



Figure:4.3 output shown in Blynk IoT

CONCLUSION

The proposed IoT-based fire protection and charge monitoring system provides an effective approach for improving the safety, reliability, and performance of Battery Management Systems (BMS) in electric vehicles. By continuously monitoring important battery parameters such as temperature, voltage, and state of charge, the system can identify abnormal operating conditions and provide timely alerts. The integration of IoT and the Blynk platform enables remote monitoring of battery conditions, while the fire protection mechanism helps reduce the risk associated with overheating and potential thermal hazards.

The developed system also supports safe and efficient charging by preventing conditions such as overcharging and undercharging, thereby contributing to improved battery performance and longevity. The combination of real-time monitoring, IoT-based communication, and protective measures makes the system suitable for enhancing EV battery safety. Further improvements can include advanced smoke and gas detection sensors and predictive maintenance techniques to provide earlier fault identification and more intelligent battery health monitoring.

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