# An Iot Based Framework for Battery Reliability and Fire Risk Monitoring In E-Vechicle

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***Abstract*—The increasing adoption of electric vehicles (EVs) has created new challenges related to battery safety and efficient charging management. Lithium-ion batteries used in EVs generate significant heat during charging and discharging cycles, making proper thermal monitoring essential. Excessive heat can lead to overheating, reduced battery lifespan, and potential thermal runaway conditions that threaten system reliability and safety. Many conventional EV charging systems lack real-time monitoring of important battery parameters such as voltage, current, and temperature. Without continuous sensing and intelligent analysis, it becomes difficult to detect abnormal conditions at an early stage, which may result in battery damage or inefficient charging performance. Fast charging technologies further increase internal battery temperature, which can cause performance degradation if not properly controlled. Integrating Internet of Things (IoT) sensors with thermal monitoring systems provides an effective solution to this problem. These sensors continuously track battery conditions and detect issues such as overheating, overvoltage, and abnormal current flow. In addition, RFID-based authentication can ensure secure user access to charging stations. A smart EV charging station with automated control and real-time monitoring improves battery protection, enhances charging efficiency, and ensures safer EV charging operations.**

***Index Terms*— Electric Vehicles (EV), IoT-Based Monitoring, Battery Thermal Management, RFID Authentication, Smart Charging System.**

## I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has created a strong demand for advanced and safe charging infrastructures. As EV adoption increases worldwide, ensuring the safety, reliability, and efficiency of battery charging systems has become a major challenge. Lithium-ion batteries, which are widely used in EVs, generate a considerable amount of heat during charging and discharging cycles. If this heat is not properly monitored and controlled, it may lead to overheating, battery degradation, reduced lifespan, or even dangerous thermal runaway conditions. Traditional EV charging systems mainly focus on power delivery and often lack real-time monitoring of important battery parameters such as voltage, current, and temperature. Without continuous monitoring and intelligent analysis, detecting abnormal charging conditions at an early stage becomes difficult, which may compromise battery safety and performance.

To address these challenges, the Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication has been developed to improve battery safety and charging efficiency. This system integrates multiple sensors to continuously measure voltage, current, and temperature of the battery during the charging process. The collected data is processed by a microcontroller that monitors the battery condition in real time and ensures safe charging operation. An LCD display unit is used to present the monitored parameters clearly, allowing users to easily observe the charging status and battery health information.

One of the important features of the system is the implementation of RFID-based authentication for secure user access. Only authorized users with a valid RFID card can initiate the charging process, which helps prevent unauthorized usage and enhances system security. In addition, the integration of Internet of Things (IoT) technology allows the collected sensor data to be transmitted to a cloud platform for remote monitoring and analysis. Through this IoT-based monitoring system, users and system administrators can observe battery parameters, detect abnormal conditions such as overheating or overcurrent, and receive alerts in real time from any location with internet access.

The microcontroller acts as the central processing unit of the system, coordinating sensor data acquisition, display functions, charging control, and communication with the IoT platform. By combining intelligent monitoring with automated control mechanisms, the system can improve charging efficiency while protecting the battery from unsafe operating conditions. Overall, the Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication provides a reliable and intelligent solution for modern EV infrastructure. By integrating sensor technologies, secure authentication, and cloud-based monitoring, the system enhances battery protection, ensures safe charging operations, and supports the development of sustainable and efficient electric mobility systems.

## II. LITERATURE REVIEW

Brahma chary, Rupali, and Irfan Ahmed [2025] stated that the rapid growth of electric vehicles has created a significant demand for efficient distribution network planning and optimal placement of EV charging stations. Their study focuses on the use of machine learning techniques for load forecasting to support the expansion of distribution networks while allocating EV charging stations effectively. By predicting future energy demand patterns, the proposed framework helps utilities plan charging infrastructure that can handle increasing EV loads without overloading the power grid. The research highlights that accurate forecasting and proper station placement are essential to maintain grid stability and improve the reliability of EV charging systems.

El-Afifi, Magda I., et al. [2025] explained that integrating EV charging stations into the power grid requires intelligent forecasting and optimization strategies. Their research introduces a hybrid forecasting framework that combines ARIMA and LSTM models to predict EV charging demand more accurately. The study demonstrates that combining statistical and deep learning methods can improve prediction performance and help in designing efficient charging infrastructure. The proposed framework also supports better energy management and reduces operational uncertainties associated with EV charging station deployment.

Kumar, Pramod, M. A. Ansari, and Rajeev Agrawal [2025] conducted a comprehensive review of recent trends in electric vehicle technologies, charging processes, and international charging standards. Their study highlights the importance of efficient charging mechanisms, battery safety, and the development of standardized charging protocols for sustainable EV adoption. The authors discuss various charging techniques such as slow charging, fast charging, and wireless charging, emphasizing the need for advanced monitoring systems to manage heat generation and improve battery performance during the charging process.

Khalil, Kiran, Zunaib Maqsood Haider, and Muhammad Ali Qureshi [2025] proposed an optimization framework designed to minimize the impact of EV charging stations on power distribution systems. Their research focuses on managing power demand fluctuations caused by large-scale EV charging. The framework evaluates different placement and scheduling strategies to reduce voltage instability and power losses in the distribution network. The results show that optimized planning of EV charging stations can significantly improve grid performance and prevent operational issues caused by uncontrolled charging loads.

Agrawal, H.P., Prashant Kumar, and Pushpendra Singh [2024] highlighted the role of Internet of Things (IoT) technology in transforming traditional EV charging stations into intelligent and automated systems. Their research presents an IoT-based charging station architecture that enables real-time monitoring, data collection, and remote control of charging operations. By integrating sensors and communication modules, the system can monitor parameters such as voltage, current, and temperature, allowing early detection of faults and improving the safety and efficiency of EV charging processes.

Yousuf, A. K. M., et al. [2024] provided an in-depth exploration of EV charging station infrastructure, discussing various technical challenges and possible mitigation strategies. Their study analyzes issues such as grid congestion, energy management, charging demand uncertainty, and infrastructure deployment. The authors also review different optimization techniques and smart charging approaches that can help manage EV charging loads more efficiently while ensuring reliable operation of the power distribution network.

Shukl, Pavitra, and Bhim Singh [2023] presented a distributed energy resources-based EV charging station that can operate with seamless grid integration. Their research focuses on incorporating renewable energy sources such as solar power into EV charging infrastructure to reduce dependency on conventional power sources. The proposed system improves energy efficiency and promotes sustainable charging solutions by combining renewable generation with intelligent control strategies.

Ahmad, Fareed, et al. [2023] studied the optimal placement and capacity planning of EV charging stations by considering uncertainties in EV demand and energy supply. Their research emphasizes the importance of energy management strategies to ensure reliable charging services while minimizing operational costs. By analyzing various demand scenarios, the study provides guidelines for planning charging infrastructure that can support future EV adoption while maintaining stable grid operation.

## III. PROPOSED SYSTEM

The Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication is designed to overcome the limitations of conventional electric vehicle charging systems by integrating advanced sensing, monitoring, and secure access technologies. Traditional EV charging stations mainly focus on delivering electrical energy to the vehicle battery but often lack intelligent monitoring mechanisms to observe important battery parameters such as voltage, current, and temperature. This limitation may lead to overheating, battery degradation, and unsafe charging conditions. The proposed system introduces a smart charging infrastructure that continuously monitors battery conditions and ensures safe and efficient charging operations.

The system incorporates multiple sensors that measure voltage, current, and temperature of the EV battery during the charging process. These sensors continuously collect real-time data and send it to a microcontroller, which acts as the central processing unit of the system. The microcontroller analyzes the sensor data and determines whether the battery is operating within safe limits. If abnormal conditions such as overvoltage, excessive current flow, or overheating are detected, the system can generate alerts and automatically control the charging process to prevent damage.

Another important feature of the proposed system is the integration of RFID-based authentication for secure user access. In this mechanism, only authorized users with valid RFID cards can activate the charging station. This ensures that the charging facility is protected from unauthorized access and misuse. When a valid RFID card is scanned, the system verifies the user identity and allows the charging process to begin. The system also includes an LCD display unit that shows important information such as battery voltage, charging current, temperature levels, and charging status. This real-time display helps users monitor the charging process easily and understand the battery condition during operation. Furthermore, the integration of Internet of Things (IoT) technology enables the collected data to be transmitted to a cloud platform. Through this platform, users and system administrators can remotely monitor charging parameters and receive alerts if any abnormal condition occurs.

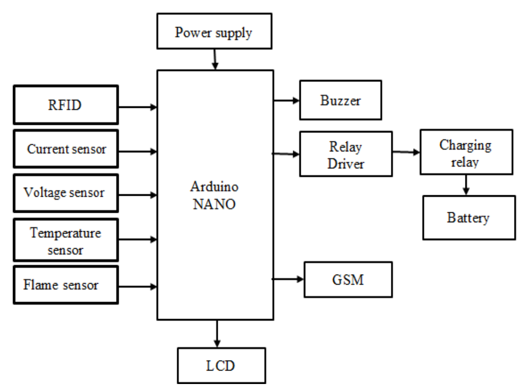


Figure 3.1 Block Diagram of the Proposed Smart EV Charging System

A key objective of the proposed system is to provide a safe, efficient, and user-friendly EV charging solution. By combining intelligent monitoring, automated control, IoT connectivity, and secure authentication, the system enhances battery protection and improves the reliability of EV charging infrastructure. This smart charging station represents an important step toward developing sustainable and intelligent electric mobility systems.

## IV. METHODOLOGY

The implementation of the Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication follows a systematic methodology to ensure efficient design, development, and deployment of the system. The first step in the process is requirement analysis, where the technical requirements of EV charging systems, battery safety standards, and user accessibility are carefully studied. This stage focuses on identifying key parameters that must be monitored during the charging process, including battery voltage, current, and temperature.

After defining the system requirements, the next step involves sensor selection and integration. Sensors capable of accurately measuring voltage, current, and temperature are selected based on reliability, precision, and compatibility with the microcontroller. These sensors are integrated into the charging system to continuously monitor battery conditions. The sensor data provides essential information that helps the system detect abnormal charging behavior.

Following sensor selection, hardware development begins. This stage involves designing the electronic circuitry and integrating key components such as the microcontroller, sensors, RFID module, LCD display, and power control unit. The microcontroller serves as the central controller responsible for processing sensor data, managing authentication procedures, and controlling the charging operation. The RFID module is integrated to enable secure access by verifying user identity before allowing the charging process to start.

Parallel to hardware development, software development is carried out to manage system operations. The software program is designed to read sensor data, process the information, and display the results on the LCD screen. It also includes safety algorithms that monitor battery parameters and trigger alerts or control actions if unsafe conditions are detected. In addition, an IoT platform is developed to transmit sensor data to the cloud for remote monitoring and analysis.

Once the hardware and software components are developed, the system proceeds to the integration stage, where all modules are combined into a working prototype. During this phase, communication between sensors, microcontroller, RFID module, LCD display, and IoT platform is verified to ensure proper system functionality.

After integration, testing and validation are performed to evaluate the system's performance under different charging conditions. Various test scenarios are conducted to verify the accuracy of sensor readings, reliability of RFID authentication, and responsiveness of the IoT monitoring system. Any issues identified during testing are corrected to improve system efficiency and safety.

Finally, the developed system is evaluated for real-world application, ensuring that it provides reliable battery monitoring, secure user authentication, and efficient charging control. Through this structured methodology, the proposed smart EV charging station successfully enhances charging safety, improves battery protection, and supports the development of intelligent EV infrastructure.

## V. RESULT AND DISCUSSION

The Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication demonstrates an effective solution for improving the safety, reliability, and efficiency of electric vehicle charging systems. The developed system successfully integrates sensors, microcontroller control, RFID authentication, and IoT connectivity to provide intelligent monitoring and control of the EV charging process. By continuously monitoring important battery parameters such as voltage, current, and temperature, the system ensures that the charging process operates within safe limits and prevents potential battery damage caused by overheating or abnormal charging conditions.

During system operation, the voltage, current, and temperature sensors accurately collect real-time data from the EV battery and transmit it to the microcontroller for processing. The processed data is displayed on the LCD screen, allowing users to observe the charging status and battery condition clearly. The experimental results show that the system can effectively detect abnormal conditions such as excessive temperature rise or abnormal current flow during charging. When such conditions occur, the system is capable of generating alerts and controlling the charging operation to protect the battery from potential damage.

| Condition | Threshold | Action Taken | Response Time |
| --- | --- | --- | --- |
| Over Temperature | > 60 °C | Charging Paused Alert Triggered | 2.3 s |
| Over Voltage | > 420 V | Charging Paused Alert Triggered | 1.8 s |
| Over Current | > 30 A | Charging Paused Alert Triggered | 2.0 s |

Figure 5.1: System Response to Abnormal Conditions

The integration of RFID authentication enhances the security of the charging station by allowing only authorized users to access the system. The RFID module successfully verifies the identity of the user before initiating the charging process, thereby preventing unauthorized usage. This feature ensures controlled access to the charging infrastructure and improves the overall safety of the system.

Another important result of the system is the successful implementation of IoT-based remote monitoring. The collected sensor data is transmitted to a cloud platform, where users and administrators can monitor charging parameters in real time. This feature allows users to track battery conditions and charging status from remote locations, making the system more convenient and user-friendly. Additionally, the remote monitoring capability helps in early detection of faults, enabling timely maintenance and improving system reliability.

The system also demonstrates high efficiency in terms of battery protection and charging management. By continuously analyzing battery parameters and responding to abnormal conditions, the proposed smart charging station reduces the risk of overheating and improves battery lifespan


Figure 5.2 Overall System performance index

Overall, the developed system proves to be a reliable and intelligent solution for modern EV charging infrastructure. The integration of sensing technologies, IoT connectivity, and secure authentication significantly enhances the performance, safety, and usability of EV charging stations.

## VI. CONCLUSION

In conclusion, the Smart EV Charging Station with IoT-Based Thermal Monitoring and RFID Authentication provides an advanced and reliable solution for improving the safety and efficiency of electric vehicle charging systems. The system successfully integrates voltage, current, and temperature sensors with a microcontroller to continuously monitor battery conditions during the charging process. This real-time monitoring capability helps detect abnormal situations such as overheating, overvoltage, and excessive current flow, thereby protecting the battery from damage and ensuring safe charging operations. The implementation of RFID-based authentication enhances the security of the charging station by allowing access only to authorized users. This feature prevents unauthorized usage and improves the management of EV charging infrastructure. In addition, the integration of IoT technology enables remote monitoring of battery parameters and charging status through cloud-based platforms. This allows users and administrators to observe system performance from any location and receive alerts in case of abnormal conditions. The developed system also provides a user-friendly interface through the LCD display, which clearly presents real-time information about battery voltage, current, temperature, and charging status. This makes the system easy to operate and monitor for users. Furthermore, the smart monitoring capability improves battery protection and contributes to longer battery lifespan by preventing unsafe charging conditions. Overall, the proposed system demonstrates the potential to enhance EV charging infrastructure by combining intelligent monitoring, secure authentication, and remote connectivity. It supports the development of safer, smarter, and more efficient electric vehicle charging systems, contributing to the advancement of sustainable transportation technologies.

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