Journals Pub

International Journal of
Electrical Power System
and Technology

ISSN: 2455-7293
Volume 11, Issue 2, 2025
July–December
DOI (Journal): 10.37628/IJEPST

https://journalspub.com/journal/ijepst/

Review IJEPST

IoT-Based Battery Management System for Electric Vehicles

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Abstract

Electric vehicles are becoming increasingly popular due to rising fuel costs and environmental concerns in contemporary applications, where energy storage systems power a wide range of devices, from small gadgets to big electric vehicles and renewable energy grids. Efficient battery management is becoming increasingly crucial. This study proposes the design and implementation of an Internet of Things-based battery management system that can continually monitor vital battery characteristics, like voltage, current, temperature, and state-of-charge, to address these issues. In contrast to traditional methods, the suggested Internet of Things-enabled framework offers wireless connectivity, remote accessibility, and real-time data collection, all of which contribute to ongoing insights into battery health. By enabling the early discovery of problems, lowering unexpected failures, and limiting downtime, this type of monitoring supports predictive maintenance plans. This prolongs the battery pack's overall lifespan in addition to improving system reliability. In addition to maximizing performance, proper management prolongs the batteries' useful life and guarantees safety by averting dangerous situations, including deep discharge, overcharging, and overheating. The suggested approach places a strong emphasis on increasing energy efficiency through clever cycle management for charging and discharging. It is useful for a variety of applications, including industrial automation systems, renewable energy storage devices, and electric cars, due to its scalability and inexpensive implementation costs. The system makes a substantial contribution to the creation of power management infrastructures that are safer, more effective, and more sustainable by fusing affordability, remote monitoring, and predictive analytics. All things considered, the study shows how Internet of Things-driven strategies can make battery management a more intelligent, proactive, and future-ready technology. The design and deployment of an Internet of Things-based battery management system that can continuously monitor vital battery characteristics is presented in this study as a solution to these issues. Such continuous monitoring helps in preventing failures and optimizing performance. By providing predictive maintenance, the system ensures early detection of issues, reducing downtime and extending battery lifespan. Furthermore, the proposed framework enhances efficiency by managing energy utilization more effectively. Its low-cost implementation and remote accessibility make it suitable for diverse applications, including electric vehicles, renewable energy storage, and industrial systems, thereby contributing to reliable power management.

Keywords: IoT, battery management system, electric vehicles, ESP8266, real-time monitoring

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Received Date: April 23, 2025
Accepted Date: September 15, 2025
Published Date: December 01, 2025

Citation: Ankita Bhosale, Pradnya Sutar, Sayee Veer, T.M. Dudhane. IoT-Based Battery Management System for Electric Vehicles. International Journal of Electrical Power System & Technology. 2025; 11(2): 1–7p.

INTRODUCTION

Effective battery management has emerged as a crucial component of electric vehicle (EV) performance due to the quick uptake of EVs. An Internet of Things (IoT)-based battery management system (BMS) developed to address the growing need for reliable and efficient power storage solutions [1]. With the rapid adoption of EVs, renewable energy systems, and portable electronics, maintaining battery health has become critical to ensure safety, performance, and long-term sustainability [2]. Conventional battery management approaches often rely on manual checks or limited monitoring, which may fail to detect issues in advance. To get around these restrictions, the suggested system uses IoT technology to monitor critical factors, including voltage, temperature, and charge level in real time. Sensors are interfaced with an ESP8266 microcontroller that gathers and processes the data before transmitting it to a secure cloud platform [3, 4]. Through this setup, users can remotely monitor battery conditions, receive instant alerts, and access historical performance trends. The system not only prevents sudden failures but also enables predictive maintenance by identifying potential risks early, thereby minimizing downtime and extending battery life. Its cost-effectiveness, scalability, and accessibility make it highly suitable for diverse applications, ensuring efficient energy utilization and reliable power management in modern systems [5]. This paper explores an IoT-enabled BMS that collects and analyzes key battery parameters to enhance energy efficiency. EVs are becoming more popular these days due to rising gasoline prices. As a result of these conditions, different automakers are searching for fuel sources other than gas [6]. Because there is less pollution when electrical fuel sources are used, the environment may benefit. Additionally, EVs offer remarkable benefits in terms of energy conservation and environmental protection. Lithium molecule batteries, which are battery-controlled, are utilized in the majority of EVs [7].

LITERATURE REVIEW

Previous research on BMS emphasizes the critical role of real-time monitoring and predictive analytics in ensuring battery safety, efficiency, and longevity. With the increasing reliance on rechargeable batteries in EVs, renewable energy systems, and portable electronics, there is a growing demand for intelligent solutions that can optimize performance while preventing failures [8]. Various approaches, including wireless power transfer, smart charging stations, and cloud-based monitoring, have been investigated to enhance reliability and energy utilization. Despite these efforts, many existing solutions still lack seamless integration with IoT frameworks, which are essential for enabling real-time diagnostics, remote monitoring, and proactive decision-making.

Our suggested approach fills these gaps by combining cloud platforms and IoT connectivity to allow for continuous monitoring of vital battery metrics, including voltage, temperature, and charge level. Using sensor data processed through the ESP8266 microcontroller, users can access live updates, receive instant notifications, and predict potential issues before they escalate. This integration not only ensures improved battery efficiency and health management but also supports predictive maintenance [9, 10]. By leveraging IoT, the system bridges current limitations and offers a reliable, scalable solution for modern energy applications.

RELATED WORKS

- *Solar-Powered Wireless Battery Chargers:* Solar-powered wireless battery chargers are increasingly used in portable and off-grid applications, offering improved energy efficiency and sustainability. By integrating renewable solar energy with wireless charging technology, these systems reduce reliance on traditional grids, enable convenient charging, and enhance portability, making them suitable for outdoor and remote environments.
- *AI-Driven BMS:* Artificial intelligence-driven BMSs leverage predictive fault analysis to monitor and optimize battery health. By analyzing real-time data trends, AI algorithms can forecast potential failures, prevent unsafe operating conditions, and extend battery lifespan. This proactive approach ensures higher efficiency, reduced maintenance costs, and improved reliability in diverse applications.
- *Monitoring Systems Based in the Cloud:* They are based in the cloud. Scalable and dependable platforms for remotely monitoring battery health are offered by cloud-based monitoring systems. These solutions store real-time data, enable user-friendly visualization, and support remote access from multiple devices. With instant notifications and predictive analytics, they enhance decision-making, ensure safety, and allow efficient management of large-scale battery networks.

SYSTEM ARCHITECTURE & METHODOLOGY

The proposed system comprises:

- *Microcontroller (ATmega328):* The system's central processing unit, the ATmega328 microcontroller, oversees processing the data gathered and interacting with several sensors. It retrieves data from the battery, including voltage, temperature, and current, and transforms them into digital signals. The processed data is then prepared for transmission to the ESP8266 Wi-Fi module for cloud integration. Its low power consumption, reliability, and compatibility with Arduino platforms make it highly efficient for managing battery-related computations in real time.
- *ESP8266 Wi-Fi Module:* The ESP8266 module provides wireless connectivity, enabling seamless communication between the microcontroller and the cloud platform. It transmits processed battery data over Wi-Fi, allowing remote monitoring and real-time updates through a cloud interface. This module ensures efficient data transfer, reducing latency and supporting instant notifications for abnormal conditions. Its built-in TCP/IP protocol stack makes it suitable for IoT-based systems. By connecting to standard networks, the ESP8266 bridges local hardware with cloud infrastructure, enabling remote accessibility and efficient battery health management.
- *Sensors:* Sensors are crucial components that monitor the key parameters of the battery, including voltage, temperature, and current. Voltage sensors measure charge levels, temperature sensors track thermal conditions, and current sensors detect flow to ensure safe operation. These readings help identify potential issues such as overheating, overcharging, or excessive discharge. The sensors provide continuous data to the microcontroller, which processes and forwards it for cloud-based monitoring. Accurate sensor inputs enable predictive maintenance, extend battery lifespan, and ensure efficient, reliability, and safe energy utilization.
- *Power Supply Module:* The power supply module ensures that all system components receive stable and regulated power for smooth functioning. It converts input power to the required voltage levels suitable for the microcontroller, sensors, and ESP8266 Wi-Fi module. For continuous operation, a dependable power source is essential, particularly when performing crucial battery monitoring duties. By preventing voltage fluctuations or drops, the module safeguards the system from instability. Its efficiency supports continuous data collection, transmission, and processing, ensuring the entire IoT-enabled BMS operates without interruption.
- *Cloud Platform:* The foundation for data storage, visualization, and remote accessibility is the cloud platform. Real-time battery data transmitted by the ESP8266 is stored in the cloud, where it is analyzed and presented through dashboards or mobile applications. Users can view voltage, temperature, and charge levels remotely, receiving instant alerts when abnormalities are detected. This platform not only supports long-term data logging for performance analysis but also enables predictive maintenance. By leveraging cloud services, the system ensures scalability, accessibility, and improved decision-making for battery management.

Block Diagram

Components Used

- *Microcontroller (ATmega328):* Interfaces with sensors and processes data.
- *ESP8266 Wi-Fi Module:* Enables cloud communication.
- *Sensors:* Voltage, temperature, and current sensors measure battery parameters.
- *Power Supply Module:* Ensures stable power delivery to the components.
- *Cloud Platform:* Stores and visualizes real-time data for users, as shown in Figure 1.

The block diagram of the proposed IoT-based BMS is illustrated below:

Workflow

Connecting the ESP8266 Wi-Fi module to the microcontroller is the first step. Because the ESP8266 is made to run at 3.3V, giving it 5V may cause malfunctions or irreversible harm. Because of this, the

ESP8266's VCC pin needs to be linked to the microcontroller's 3.3V output. Additionally, a straight 5V connection may prevent communication because the module's RX pin operates at a 3.3V logic level. In this setup, pin 3 of the microcontroller is connected to the ESP8266's TX pin, and pin 4 is connected to the RX pin. The setup includes an LM05 sensor to track temperature. The microcontroller's pin 25 is linked to the sensor's output. With the SCL line attached to pin 28 and the SDA line attached to pin 27 of the microcontroller, the I²C interface is also used. The microcontroller's pin 13 is linked to a buzzer. Every time the system senses unusual operating conditions, like overheating or erratic voltage fluctuations, this buzzer sounds like an alert mechanism. Attach the SCL to pin 28 and the SDA to pin 27 of the microcontrollers and connect the LM05 temperature sensor to pin 25 (Figure 2). Attach a buzzer, which will begin to sound when the condition is met, to pin 13 of the microcontrollers. The LCD and microcontroller will be connected. The LCD's connectors are as follows:

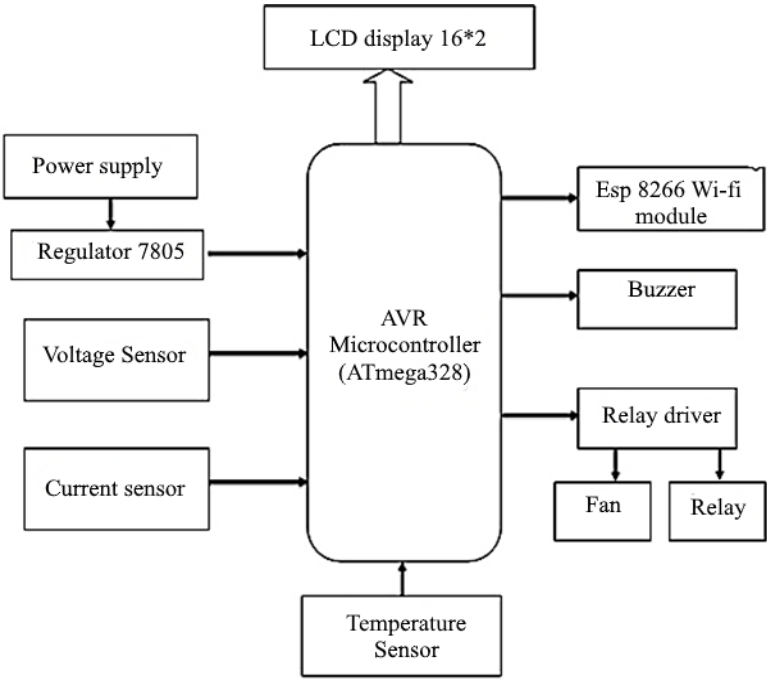

Figure 1. Block diagram workflow.

- Connect pin 1 (VEE) to ground.
- Attach to the +5V supply (VDD/VCC).
- Pin 3 (V0) to a 10K potentiometer's center terminal. The potentiometer's two outside terminals ought to be linked to GND and VCC. This enables the display contrast to be adjusted. The most typical potentiometer is 10K; however, other values might work as well.
- Pin 4 (RS) to the microcontroller's pin 14.
- Pin 5 (R/W) straight to GND. Since this pin is rarely needed for everyday applications, grounding it keeps the LCD in write mode.
- Attach pin 6 (E) to the microcontroller's pin 15. The control pins that are utilized to transmit characters and data are RS and E.

The four data pins listed below are utilized to connect to the microcontroller.

Algorithm

- *Start:* The process begins.
- *Initiate LCD and Port Direction:* The system initializes the LCD and configures the input/output ports.

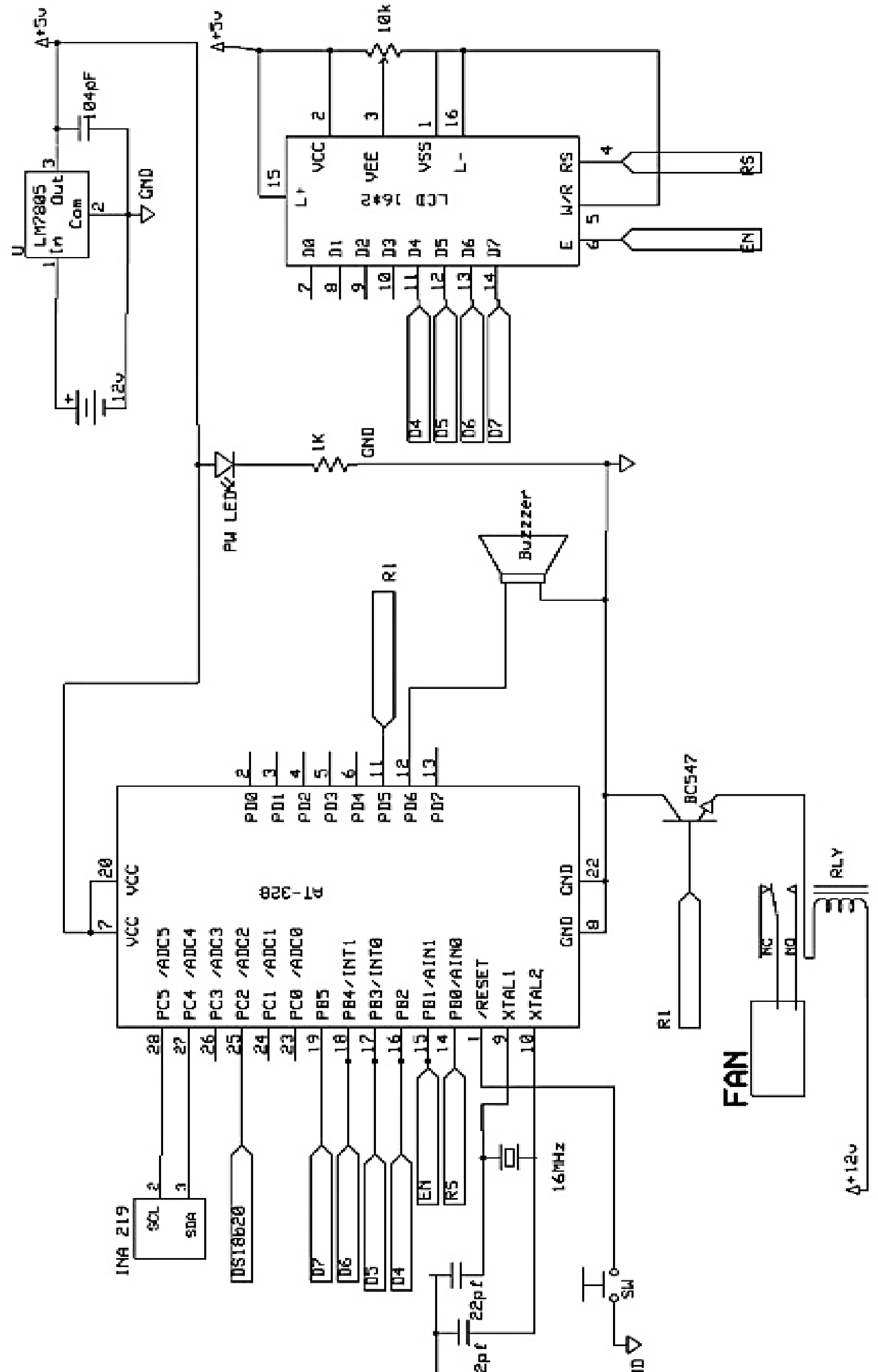

Figure 2. Circuit diagram.

- *Get Sensor Data:* The system retrieves data from a connected sensor.
- *Set Threshold:* A predefined threshold is set for comparison.
- *Threshold Exceed:* The system checks if the sensor data surpasses the threshold.
- *Yes:* The system turns OFF the relay.
- *No:* The system turns ON the relay and sends data for logging or display on the LCD.

Turn on Relay

Check Balance

- *Send Cloud Data Display Reading on LCD:* The collected data is sent to the cloud server and displayed on an LCD screen.
- *Stop:* The process ends.

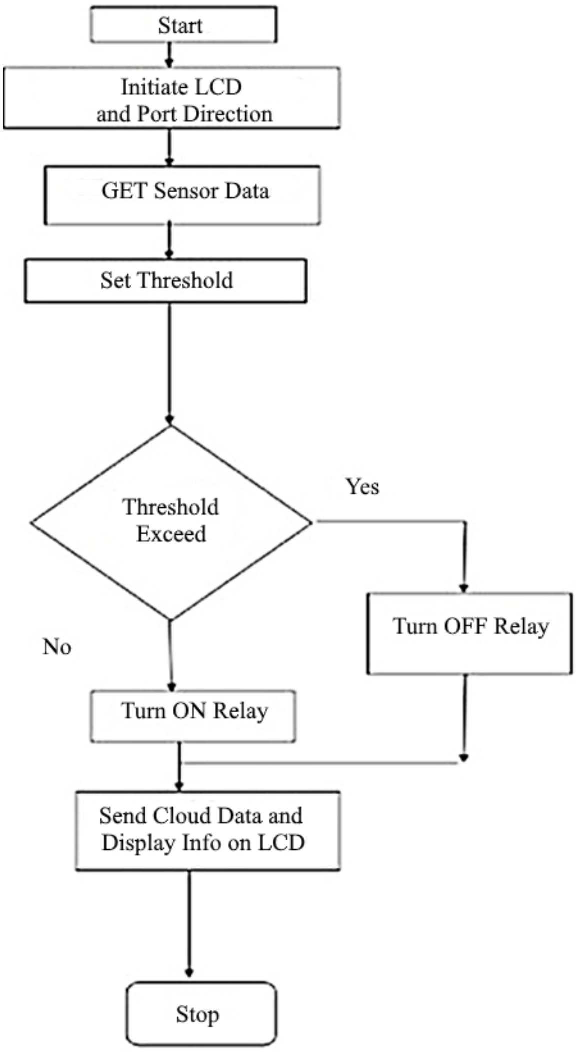

Figure 3. Flow chart turn on relay.

EXPERIMENTAL RESULTS & DISCUSSION

The prototype system successfully monitors and transmits battery parameters in real time.
Experimental results demonstrate:

- *Accurate Voltage and Temperature Readings:* The prototype system provides highly accurate voltage and temperature measurements, with minimal deviation from reference standards, ensuring reliability of monitoring and enabling effective assessment of battery health in real-time conditions, as shown in Figure 3.

- *Immediate Alert Generation:* Critical conditions, such as overcharging and overheating, trigger instant alerts from the system, enabling timely preventive action, enhancing safety, and protecting battery performance from potential failures or long-term damage.
- *Seamless Cloud Connectivity:* The system ensures seamless cloud connectivity with minimal latency, enabling real-time data transmission and quick response times, thereby supporting efficient remote monitoring and faster decision-making for battery management applications (from observation, Table 1).

Table 1. Observations from testing.

Parameter	Expected Values	Measured Values
Battery voltage	12V	11.98V
Temperature	35°C	34.8°C
Current drawn	1.5A	1.48A

CONCLUSION

The IoT-based BMS offers real-time insights into critical battery health parameters, thereby improving operational efficiency, safety, and reliability in EVs. By continuously monitoring voltage, temperature, and charge status, the system ensures timely detection of abnormalities and supports predictive maintenance to extend battery lifespan. Looking ahead, future enhancements are envisioned to further strengthen its capabilities. The integration of AI-based predictive analytics can optimize battery performance by forecasting degradation trends and suggesting efficient usage patterns. Additionally, coupling the BMS with renewable energy sources will promote sustainable EV charging, reducing dependency on conventional grids and lowering environmental impact. Another significant direction is expanding compatibility with multiple battery chemistries, such as lithium-ion, solid-state, and nickel–metal hydride, enabling adaptability across diverse EV applications. With these improvements, the IoT-based BMS will evolve into a comprehensive solution supporting smarter, safer, and greener mobility.

REFERENCES

1. Bharathi SH. Turkish J Comput Math Educ. 2021;12(13):3524–8.
2. Prabakaran S. Smart battery management system for electric vehicles using IoT technology. 2023.
3. UG Scholar. Int J Appl Eng Res. 2018;13(8):5711–4.
4. Abd Wahab MH, Anuar NI, Ambar R, Baharum A, Shanta S, Sulaiman MS, et al. IoT-based battery monitoring system for electric vehicle. Int J Eng Technol. 2018;7(4.31):505–10.
5. Ghuge DN, Vishal D, Kunal B, Kulkarni M. IoT based battery management system for electric vehicles. In: Proc 3rd Int Conf Commun Inf Process (ICCIP); 2021 Jun 26.
6. Kumar S, Ramaswamy KC, Mathiyalagan SR, Giri J, Kanan M. An efficient battery management system for electric vehicles using IoT & blockchain. Results Eng. 2025:106284.
7. Mohammadi F, Rashidzadeh R. An overview of IoT-enabled monitoring and control systems for electric vehicles. IEEE Instrum Meas Mag. 2021;24(3):91–7.
8. Haldar S, Mondal S, Mondal A, Banerjee R. Battery management system using state of charge estimation: an IoT based approach. In: 2020 Natl Conf Emerg Trends Sustain Technol Eng Appl (NCETSTEA). IEEE; 2020 Feb 7. p. 1–5.
9. Surendar M, Pradeepa P. An IoT-based battery surveillance system for E-vehicles. In: 2021 5th Int Conf I-SMAC (IoT Soc Mob Anal Cloud) (I-SMAC). IEEE; 2021 Nov 11. p. 119–24.
10. Jadhav SP, Mulla AC, Argade SG, Jadhav SS, Patil D, Vaidya HD. Development of IoT based battery management system for EV. In: 2024 Int Conf Intell Syst Adv Appl (ICISAA). IEEE; 2024 Oct 25. p. 1–6.