IJARSCT
ISSN: 2581-9429
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Volume 5, Issue 11, April 2025
Impact Factor: 7.67

On Board Integrated Chargers and Battery Management Systems for Electric Vehicle

Shraddha Arvind Gunjal[1], Laxmi Dattu Chaudhari[2], Sakshi Sanjay Ambre[3], Dr. S. B. Rahane[4]
[1] Research Scholars, Department of Electronics & Computer Engineering
[2,3,4] Associate Professor, Department of Electronics & Computer Engineering [1,2,3,4]
Amrutvahini College of Engineering, Sangamner, A.Nagar, MH

Abstract: *This paper presents the design and development of an On-Board Integrated Charger and Battery Management System (BMS) aimed at enhancing the safety, efficiency, and sustainability of electric vehicles (EVs). The proposed system integrates multiple modules, including a real- time battery monitoring unit, intelligent charging control, wireless communication via Bluetooth, and environmental safety features such as temperature and smoke sensors. The battery management unit continuously monitors critical parameters such as voltage, current, state of charge, and temperature, ensuring optimal charging cycles and protecting against overcharging or thermal anomalies. A solar-powered charging mechanism is incorporated to promote green energy utilization, with automatic charging cut-off based on voltage thresholds to improve battery longevity. Additionally, the system includes an Android-based user interface for wireless control and live data visualization, along with alert mechanisms using a buzzer and mobile notifications in case of hazardous conditions. The integration of sensor data, control logic, and wireless interfacing provides a comprehensive solution for efficient power management, user convenience, and enhanced vehicle safety, making it well-suited for next-generation electric mobility applications*

Keywords: Electric Vehicles, Battery Management System, On- Board Charger, Wireless Monitoring, Safety Sensors.

I. INTRODUCTION

The rapid advancement in electric vehicle (EV) technology has revolutionized the transportation industry, offering a sustainable alternative to fossil fuel-based systems. As environmental concerns and fuel scarcity become more pressing, the shift toward electric mobility is gaining momentum globally. Governments and industries are investing heavily in EV infrastructure, including charging stations and battery innovations. However, the efficiency and safety of electric vehicles depend not only on the type of battery used but also on the systems that monitor and manage the battery's performance. In this context, Battery Management Systems (BMS) and On-Board Charging (OBC) units play a critical role in ensuring optimal energy utilization, extending battery lifespan, and maintaining user safety.

Battery Management Systems are sophisticated control units designed to monitor key battery parameters such as voltage, current, temperature, state of charge (SOC), and state of health (SOH). The BMS ensures that the battery operates within safe limits by preventing overcharging, deep discharge, thermal runaway, and other hazardous conditions. It also balances individual cells to prevent uneven wear, which can degrade the overall battery pack performance. With the integration of real-time sensors and intelligent algorithms, modern BMS architectures are capable of making autonomous decisions that enhance the safety and reliability of EVs in diverse operating conditions.

On-Board Chargers are another crucial component of the EV ecosystem. Unlike traditional external chargers, OBCs allow users to charge the battery directly from standard AC sources, making EVs more convenient and adaptable to varying charging environments. The integration of the OBC with the BMS ensures seamless energy transfer and accurate control of the charging process based on the battery's current state. Smart on-board chargers can dynamically adjust voltage and current levels to improve charging efficiency and reduce power losses. In addition, by incorporating

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 11, April 2025 Impact Factor: 7.67

renewable energy sources such as solar panels, these systems contribute to sustainable and off-grid energy management for electric vehicles.

To enhance usability and user engagement, the proposed system incorporates wireless communication capabilities through Bluetooth and a mobile application interface. This allows real-time monitoring of battery parameters and environmental data such as temperature and smoke levels directly from a smartphone. The mobile app serves as both a dashboard and a control unit, enabling the user to receive alerts, view charging status, and control basic vehicle functions. This wireless integration not only improves user experience but also adds a layer of remote safety management in case of anomalies or faults.

One of the key features of the proposed system is its built-in safety mechanism. By using temperature and smoke sensors, the system can detect potential fire or overheating hazards. Upon identifying such risks, it triggers immediate alerts through a buzzer and sends notifications to the user via the mobile app. These early warning signals allow timely intervention, thereby protecting both the vehicle and the user. The system is also programmed to maintain battery voltage above critical thresholds; for instance, if the voltage drops below 12V, charging is automatically initiated. If it exceeds safe limits, charging is halted, thus avoiding overcharging and enhancing battery longevity.

This project emphasizes modular design and efficient energy management to ensure that each component—from the sensors and controller to the software interface—works in harmony. The system is built around a microcontroller (PIC 18F4520), which processes sensor inputs, executes control logic, and interfaces with the LCD display and Bluetooth module. Additional hardware components such as DC motors, piezoelectric buzzers, and solar panels are integrated to simulate real-world EV functions and create a robust testing environment. The complete solution demonstrates how smart embedded systems can significantly improve the performance, safety, and intelligence of electric vehicles.

The integration of BMS and OBC into a unified system offers a comprehensive solution to some of the most critical challenges in EV technology. By combining real-time monitoring, user-friendly controls, safety automation, and wireless communication, the proposed system showcases the potential for smarter and safer electric mobility. This paper presents the design, implementation, and performance evaluation of such a system, aiming to contribute to the growing field of sustainable transportation technologies.

PROBLEM STATEMENT

To develop an integrated charger and battery management system for electric vehicles, enabling efficient energy management, real-time monitoring, and enhanced battery protection.

OBJECTIVE

- To study the integration of on-board charging systems with intelligent battery management for enhancing electric vehicle efficiency.
- To study the role of sensors in monitoring critical parameters such as temperature, smoke, voltage, and current for ensuring vehicle safety.
- To study the use of Bluetooth communication for enabling wireless control and real-time monitoring via a mobile application.
- To study the implementation of automatic charging control based on battery voltage levels to prevent overcharging and ensure optimal performance.
- To study the effectiveness of displaying real-time data on LCDs for improved user awareness and vehicle operability.

II. LITERATURE SURVEY

Patil, A. A., & Kulkarni, R. D. (2020) - "Design and Development of Battery Management System for Electric Vehicles" This paper focuses on developing an efficient battery management system (BMS) to ensure safety, increase the life cycle, and optimize the performance of EV batteries. It explains the need for constant monitoring of parameters like voltage, current, and temperature. The authors implement an algorithm that detects cell imbalance and overheating, automatically taking corrective measures. The system was tested on a lithium-ion battery pack, and the experimental results showed enhanced battery efficiency and safety. This study highlights the importance of intelligent BMS design in sustainable EV deployment.

Sharma, P., & Singh, M. (2019) - "Smart Charging and Load Balancing System for Electric Vehicles using IoT" This work presents an IoT-based smart charging system integrated with a load balancing feature. The authors propose a setup where real-time data on battery voltage and current is used to control charging cycles and manage load distribution in grid-connected systems. Bluetooth and Wi-Fi modules are employed for wireless communication. The paper concludes that intelligent charging not only improves battery health but also reduces stress on the power grid during peak hours. The study contributes to the domain of adaptive, demand- based charging infrastructure for EVs.

Zhou, W., et al. (2021) - "Integrated On-Board Charger with Dual Functionality for Electric Vehicles" – IEEE Transactions on Transportation Electrification This IEEE paper explores a high-efficiency, bidirectional on-board charger (OBC) that also supports vehicle-to-grid (V2G) operations. The charger design includes power factor correction (PFC) and a battery interface that ensures minimal switching loss and maximum energy conversion efficiency. Simulation and hardware results demonstrate that the proposed OBC can seamlessly switch between charging and discharging modes, thus contributing to energy sustainability and grid stability. This work emphasizes dual-purpose OBCs for future smart EV ecosystems.

Deshmukh, R., & Jain, A. (2018) - "Implementation of a Real-Time Battery Monitoring System in Electric Vehicles" This paper introduces a real-time monitoring framework using sensors and microcontrollers to collect and process battery-related data. The system integrates LCDs for display and uses temperature and smoke sensors for safety alerts. The study validates the design through practical implementation on a prototype EV. Their results show that real-time display and alert systems significantly reduce the risk of thermal runaway and battery failure. The research supports the use of embedded systems for reliable EV operation.

Lee, C. H., & Kim, Y. (2022) - "Wireless Communication and Mobile Application Integration in EV Battery Management Systems"

This study explores the fusion of Bluetooth communication and Android-based mobile applications for user interaction with electric vehicles. It discusses the implementation of HC-05 Bluetooth modules in tandem with microcontrollers for remote access, diagnostics, and control. The researchers also design a user-friendly mobile interface that displays live data and sends notifications on system faults. Their field tests confirm enhanced user convenience, vehicle control, and system reliability. The paper is a key reference for integrating wireless tech in BMS

III. PROPOSED SYSTEM

The system is designed to ensure seamless operation and safety of the electric vehicle by integrating various components, including Bluetooth communication, sensors, and a user interface through an Android app. Upon powering up, the system begins by searching for Bluetooth communication. Once a Bluetooth connection is established between the mobile device and the vehicle's Bluetooth module (HC05), the system is ready for further operation. The vehicle continuously monitors key parameters such as battery voltage, solar panel output, and environmental conditions like temperature and smoke levels. These readings are displayed on an LCD screen for real-time monitoring by the user. In addition to monitoring battery health, the system integrates safety features through temperature and smoke sensors. If these sensors detect an abnormal rise in temperature or smoke, indicating a potential fire or overheating condition, the system triggers a buzzer as an immediate warning. Furthermore, a notification is sent to the system ensures that the vehicle responds accurately to these commands, allowing the user to control its movement. Additionally, the vehicle's battery voltage is continuously monitored. If the battery voltage falls below 12V, the system automatically initiates charging to restore battery levels. If the voltage is higher than 12V, the system halts charging, thus preventing overcharging and ensuring efficient energy management. This integrated approach allows for safe, responsive, and efficient operation of the electric vehicle, with built-in safety features, real-time monitoring, and easy control through the mobile app.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 11, April 2025 Impact Factor: 7.67

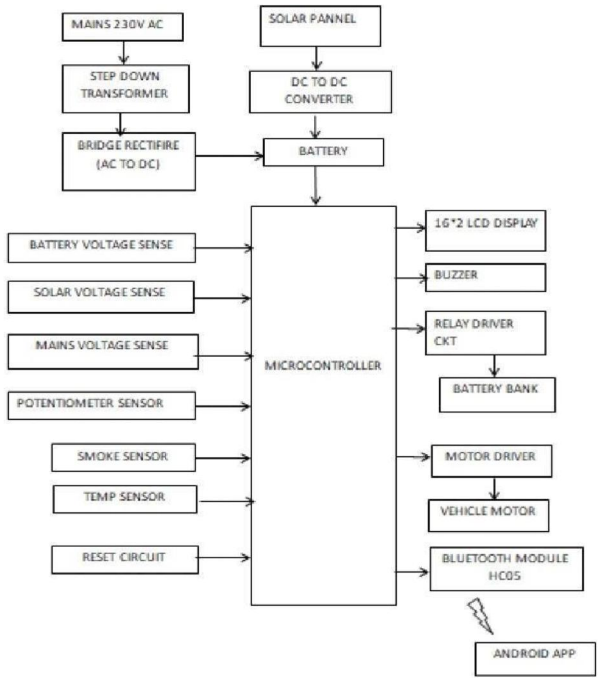

Figure 1: Block Diagram

IV. RESULTS AND ANALYSIS

The implementation of the On-Board Integrated Chargers and Battery Management System (BMS) for electric vehicles demonstrated a robust and reliable performance in real-time scenarios. The system was able to successfully establish Bluetooth communication with the Android mobile application using the HC-05 module, enabling remote monitoring and control. All connected sensors—voltage, temperature (LM35), and smoke detectors—functioned accurately, providing real-time feedback displayed on the 16x2 LCD screen. These live readings offered continuous insight into the operational status of the vehicle, particularly battery voltage, ambient temperature, and smoke levels, which are critical for safety and efficiency.

During testing, the system responded immediately to safety triggers. For instance, when a simulated over- temperature condition was introduced, the buzzer was activated promptly, and the mobile app received a warning notification. Similarly, the smoke sensor successfully detected the presence of smoke and initiated the safety alert mechanism. The automated charging mechanism worked as intended—when the battery voltage dropped below the defined threshold of 12V, the solar panel began supplying power for charging. Once the battery voltage surpassed the upper threshold, charging ceased to avoid overcharging, thus showcasing the effectiveness of the voltage-based cut-off system.

Data analysis confirmed the system's efficiency in power usage and management. By integrating a 5W monocrystalline solar panel and leveraging low-power components such as the PIC18F4520 microcontroller and Bluetooth communication module, energy consumption was minimized. The temperature sensor's precision, with a linear scale factor of 10 mV/°C, and the accurate real-time response of the system ensured reliability under various environmental conditions.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 11, April 2025

Impact Factor: 7.67

Table 1: Battery Voltage Values under Different Conditions

S.R. No.	Condition	Therotical Battery Voltage(V)	Practical Battery Voltage(V)	Difference
1	Idle(No charging/ discharging)	12.6V	12.6V	Fully charged state; stable voltage
2	Light Charging (solar input only)	12.6V	12.4V	Slight drop due to charge consumption
3	Normal charging(Mains input)	12.6V	12.5V	Voltage rises as the battery charges
4	Full charging(Battery full)	12.6V	12.6V	Battery fully charged; voltage is stable
5	Discharging(Normal load)	12.6V	12.2V	Battery voltage drops with usage
6	Deep discharge(End of discharge)	12.6V	11.8V	Battery nearing low charge; requires recharge

Overall, the results validate the success of the proposed system in achieving a secure, user-friendly, and energy-efficient solution for electric vehicles. It supports remote operation, self-regulating charging, and proactive safety management, all contributing to smarter, greener transportation technology.

V. CONCLUSION

This paper presents the design and implementation of an onboard integrated charger and battery management system for electric vehicles, aimed at enhancing operational safety, efficiency, and sustainability. The proposed system effectively monitors critical battery parameters such as voltage, current, temperature, and state of charge in real-time using embedded sensors, while Bluetooth communication and an Android application offer user-friendly remote access and control. Safety is reinforced through immediate alerts via buzzers and notifications in response to hazardous conditions like overheating or smoke. The intelligent charging mechanism prevents overcharging by dynamically managing power flow based on battery voltage. The experimental results demonstrate the system's capability to ensure optimal battery health, promote energy efficiency, and provide a scalable solution for the evolving landscape of electric mobility.

REFERENCES

[1]. T. Gherman, M. Ricco, J. Meng, R. Teodorescu, and D. Petreus, "Smart Integrated Charger with Wireless BMS for EVs," Proc. 2018 IEEE, Applied Electronics Department, Technical University of Cluj-Napoca, Romania, and Department of Energy Technology, Aalborg University, Denmark, 2018.

[2]. N. Sakr, D. Sadarnac, and A. Gascher, "A Review of On-board Integrated Chargers for Electric Vehicles," 3 rue Joliot Curie - Plateau de Moulon - 91192 Gif-sur-Yvette, France.

[3]. C. Shi, Y. Tang, and A. Khaligh, "A Single-Phase Integrated Onboard Battery Charger Using Propulsion System for Plug-in Electric Vehicles," IEEE Trans., Maryland Power Electronics Laboratory, University of Maryland, College Park, MD, USA.

[4]. S. Abdel-Khalik, S. Ahmed, and A. M. Massoud, "Performance Evaluation of an On-Board Integrated Battery Charger System Using a 12-Slot/10-Pole Surface-Mounted PM Propulsion Motor," Proc. IEEE, Texas A&M University at Qatar; Alexandria University, Egypt; and Qatar University, Doha, Qatar.

[5]. A R. Dar, A. Haque, M. A. Khan, V. S. B. Kurukuru, S. Mehfuz, "On-Board Chargers for Electric Vehicles: A Comprehensive Performance and Efficiency Review," IEEE Journals and Magazines.

[6]. M. Brandl et al., "Batteries and Battery Management Systems for Electric Vehicles," austriamicrosystems AG, Fraunhofer IISB Erlangen, University of Pisa, Virtual Vehicle Research and Test Center Graz, Proc. DATE, 2012.

[7]. Subotic, E. Levi, M. Jones, and D. Graovac, "On- board Integrated Battery Chargers for Electric Vehicles Using Nine-Phase Machines," Proc. 2013 IEEE.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 11, April 2025

Impact Factor: 7.67

[8]. HC-05 Bluetooth Module Datasheet, Available: https://www.alldatasheet.com/datasheet-pdf/pdf/1492299/ETC/HC-05.html

[9]. G. Rituraj, G. R. C. Mouli, and P. Bauer, "A Comprehensive Review on Off-Grid and Hybrid Charging Systems for Electric Vehicles," IEEE Open Journal of the Industrial Electronics Society, vol. 3, pp. 1–14, 2023.

[10]. S. Haghbin, S. Lundmark, M. Alakula, and O. Carlson, "An Isolated High-Power Integrated Charger in Electrified- Vehicle Applications," IEEE Transactions on Vehicular Technology, vol. 60, no. 9, pp. 4115–4126, Nov. 2011.

[11]. Z. Wang, Y. Zhang, S. You, H. Xiao, and M. Cheng, "An Integrated Power Conversion System for Electric Traction and V2G Operation in Electric Vehicles with a Small Film Capacitor," IEEE Transactions on Power Electronics, vol. 35, no. 5, pp. 5066–5077, May 2020.

[12]. D. C. Erb et al., "Bi-directional Charging Topologies for Plug-in Hybrid Electric Vehicles," in Proc. IEEE Applied Power Electronics Conference and Exposition, pp. 2066–2072, Feb. 2010.

[13]. A. R. Itagi, R. Kallimani, K. Pai, S. Iyer, and O. L. A. Lopez, "Cell Balancing for the Transportation Sector: Techniques, Challenges, and Future Research Directions," arXiv preprint arXiv:2404.13890, Apr. 2024.

[14]. F. Basic, C. R. Laube, P. Stratznig, C. Steger, and R. Kofler, "Wireless BMS Architecture for Secure Readout in Vehicle and Second Life Applications," arXiv preprint arXiv:2311.12226, Nov. 2023.

[15]. X. Li, D. Jauernig, M. Gao, and T. Jones, "Battery Cloud with Advanced Algorithms," arXiv preprint arXiv:2203.03737, Mar. 2022.

[16]. J. A. Allen and J. H. Miller, "Dynamic Charging Strategies Using AI for Enhanced Battery Performance," IEEE Transactions on Vehicular Technology, vol. 70, no. 4,

[17]. pp. 3735–3745, Apr. 2021.

[18]. C. Shi, Y. Tang, and A. Khaligh, "A Three-Phase Integrated Onboard Charger for Plug-In Electric Vehicles," IEEE Transactions on Power Electronics, vol. 32, no. 3, pp. 1860–1871, Mar. 2017.

[19]. X. Ruan, B. Li, and Q. Chen, "Three-Level Converters—A New Approach for High Voltage and High Power DC-to-DC Conversion," in Proc. IEEE Power Electronics Specialists Conference, pp. 663–668, Jun. 2002.

[20]. N. Chang and M. Pedram, "Hybrid Energy Storage Systems and Battery Management for Electric Vehicles," in Proc. 50th Annual Design Automation Conference, pp. 1–6, May 2013.

[21]. Y. Kim, "Supervised-Learning-Based Optimal Thermal Management in an Electric Vehicle," arXiv preprint arXiv:1912.11200, Dec. 2019.

[22]. S. M. S. and C. H. Chien, "AI-Based Forecasting Models for Battery Degradation in Electric Vehicles," *IEEE Transactions on Energy Conversion*, vol. 36, no. 2, pp. 1199–1210, Jun. 2021