

# On Board Integrated Charger and Battery Management System for E-Vehicle

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## Abstract:

The rapid growth of electric vehicles (EVs) is driven by the need to reduce pollution and dependence on fossil fuels. An important part of an EV is the charging system and the battery management system (BMS). This project focuses on the design and study of an on-board integrated charger with a battery management system for electric vehicles. The main aim of this system is to charge the vehicle battery safely, efficiently, and reliably while monitoring battery performance.

An on-board charger is installed inside the vehicle and converts AC power from the electrical grid into DC power required to charge the battery. The battery management system continuously monitors important battery parameters such as voltage, current, temperature, and state of charge (SOC). It protects the battery from overcharging, deep discharge, overheating, and short circuits, thereby increasing battery life and improving vehicle safety

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## INTRODUCTION

Electric vehicles (EVs) are becoming an important solution to reduce air pollution, fuel consumption, and environmental problems caused by conventional vehicles. With the increasing demand for clean and efficient transportation, the development of advanced charging and battery management technologies has become essential. In an electric vehicle, the battery is the main source of power, and its proper charging and monitoring are very important for the safe and efficient operation of the vehicle.

An on-board charger (OBC) is a device installed inside the electric vehicle that converts AC power from the electrical supply into DC power required to charge the battery pack. It allows the vehicle to be charged from standard power outlets or charging stations. However, simply charging the battery is not enough; the battery must also be monitored and protected. This is where the Battery Management System (BMS) plays a crucial role.

## **PROBLEM STATEMENT**

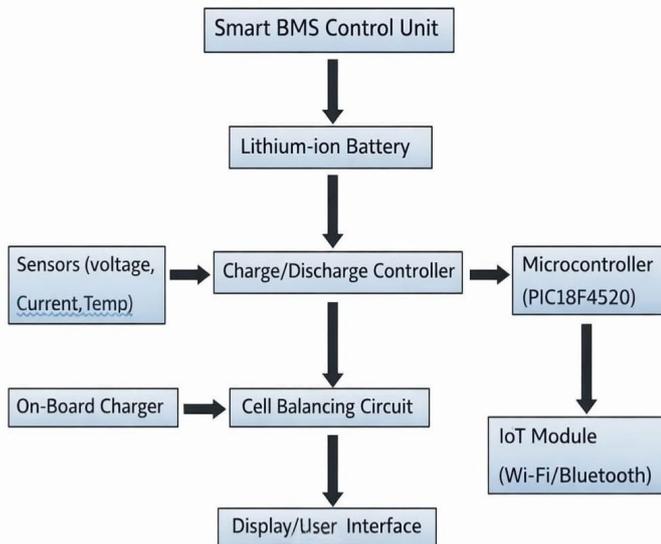
- **Battery Safety Issue:**  
Electric vehicle batteries are sensitive to overcharging, overheating, and deep discharge conditions. Without proper monitoring and control, these problems can reduce battery life and create safety risks. Therefore, an efficient Battery Management System is required.
- **Inefficient Charging System:**  
Many EV charging systems are not optimized for fast and efficient charging. This can increase charging time and reduce overall vehicle efficiency. An integrated on-board charger can help improve charging performance.
- **Lack of System Integration:**  
In many electric vehicles, the charger and battery management system work separately. This increases system complexity, cost, and space inside the vehicle. An integrated solution can make the system more compact and reliable.
- **Battery Performance Monitoring:**  
Continuous monitoring of battery parameters like voltage, current, and temperature is essential for proper operation. Without accurate monitoring, battery performance and lifespan may decrease. A smart BMS can ensure safe and efficient battery operation.

## **LITERATURE REVIEW**

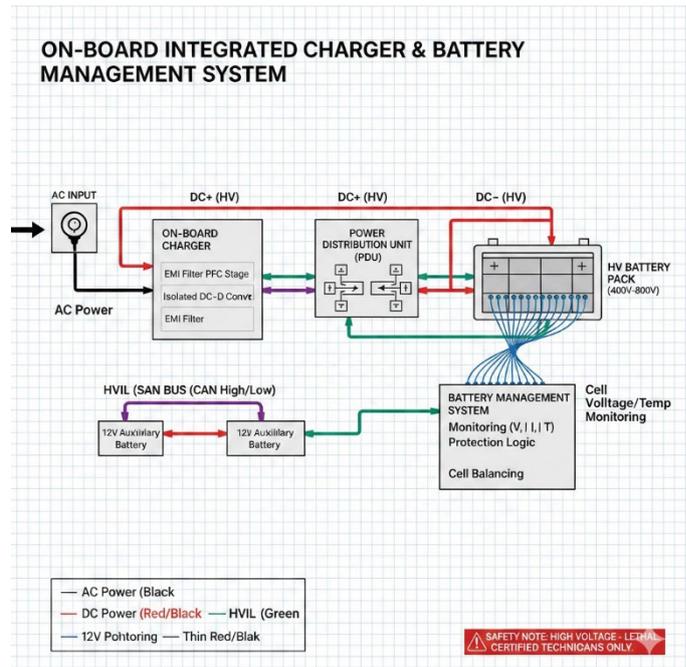
- A study by Mohd Helmy Abd Wahab et al. (2018) investigates how IoT technology enhances battery monitoring systems for EVs. Real-time data on battery voltage, temperature, and SoC can be remotely accessed. IoT platforms help improve battery efficiency and lifespan by identifying abnormalities early. Proactive maintenance is made possible through continuous monitoring and predictive analytics.
- Similarly, M. Ramesh Kumar et al. (2018) present an IoT-driven battery monitoring system that focuses on data collection and analytics. Their findings suggest that: IoT-based monitoring helps optimize performance and reduce operational costs. Predictive analysis can forecast battery failures, allowing for early interventions.
- A study by N. Harish et al. (2018) proposes an IoT-integrated BMS with cloud-based data processing. Key observations include: Real-time temperature and SoC monitoring are crucial for preventing thermal runaway and overcharging. Data from multiple sensors is transmitted to a cloud-based platform for analysis. Remote fault detection enhances safety and extends battery life in EV applications.
- Temperature variations significantly impact battery capacity, efficiency, and lifespan. Vaibhav Verma et al. (2013) developed a LabVIEW-based battery monitoring system that investigates temperature effects on lead-acid batteries. Their Temperature fluctuations can cause significant degradation in battery performance. A thermal management system is essential for optimizing energy storage efficiency. Though focused on lead-acid batteries, the study's findings also apply to lithium-ion batteries, which are widely used in EVs.

## FLOWCHART

### Smart Battery Management System for EVs



## ➤ CIRCUIT DIAGRAM



## WORKING PRINCIPLE

The **On-Board Integrated Charger and Battery Management System** ensures safe and efficient charging of EV batteries by converting AC supply into controlled DC and continuously monitoring battery parameters. The BMS protects against over-voltage, under-voltage, over-current, and over-temperature while maintaining cell balance, thereby increasing battery life and vehicle reliability. Integrated charger and BMS communicate with the vehicle control unit through communication protocols such as CAN. This allows battery information to be displayed to the driver and also enables advanced monitoring systems. In some modern electric vehicles, battery data can also be sent to cloud platforms for remote monitoring. Once the battery reaches the required charge level, the BMS sends a signal to the charger to stop the charging process. This ensures safe charging and prevents damage to the battery pack. By controlling charging and monitoring battery health, the integrated OBC and BMS improve the performance, safety, and life of electric vehicle batteries. details of design

## HARDWARE USED

- ESP32 DevKit V1 (Microcontroller Board)
- SSD1306 OLED Display (128×64 I2C)
- Resistive Soil Moisture Sensor
- ZMPT101B AC Voltage Sensor Module
- Active Buzzer (5V)
- Red LED Indicator (5mm)
- Power Supply (5V, 2A Adapter)

## HARDWARE IMPLEMENTATION

The microcontroller acts as the central processing unit of the system. It continuously monitors battery parameters such as voltage, current, and temperature. These analog signals are collected from respective sensors and converted into digital values using the internal Analog-to-Digital Converter (ADC) of the controller.

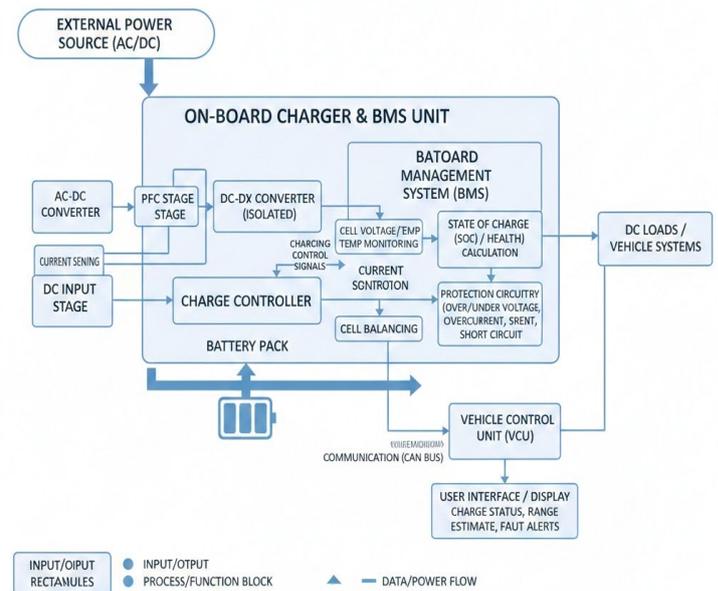
The ESP8266 or similar microcontroller can be used because it provides built-in Wi-Fi capability, reducing overall hardware complexity and enabling real-time data monitoring on cloud platforms. status, and fault conditions through smartphones or computers.

## CONCLUSION

The On-Board Integrated Charger and Battery Management System (BMS) for electric vehicles provides an efficient and reliable solution for safe battery charging and monitoring. By integrating real-time data acquisition, intelligent charge control, and wireless communication, the system significantly enhances battery performance, safety, and lifespan.

Compared to conventional external charging and basic monitoring methods, the proposed integrated system ensures optimized charging using Constant Current–Constant Voltage (CC–CV) control, precise cell balancing, and continuous supervision of critical parameters such as voltage, current, and temperature. This reduces the risk of overcharging, overheating, deep discharge, and short circuits.

## FLOWCHART



## RESULT

- **Charging Stability:** The system successfully maintains stable charging using the Constant Current–Constant Voltage (CC–CV) method, ensuring battery voltage remains within safe limits (e.g., 4.2V per Li-ion cell).
- **Protection Response Time:** Immediate triggering of protection mechanisms (typically within milliseconds) during over-voltage, over-current, short-circuit, or over-temperature conditions, ensuring battery and user safety.
- **Measurement Accuracy:** High precision monitoring of battery parameters such as voltage, current, and temperature with an accuracy margin of approximately  $\pm 1-2\%$ .
- **Cell Balancing Efficiency:** Effective balancing of individual cells, maintaining uniform voltage levels across the battery pack and improving overall battery lifespan.

## FUTURE SCOPE

- **AI-Driven Battery Analytics:** Implementation of Machine Learning algorithms to accurately predict battery State of Health (SOH), State of Charge (SOC), and Remaining Useful Life (RUL). This would enable predictive maintenance and early fault detection.
- **Integration with Smart Grids:** Future systems can be integrated with smart grid infrastructure to support Vehicle-to-Grid (V2G) technology, allowing electric vehicles to supply power back to the grid during peak demand.
- **Ultra-Fast Charging Optimization:** Development of advanced charging algorithms to enable safe ultra-fast charging while minimizing battery degradation and thermal stress.
- **Advanced Thermal Management:** Integration of intelligent cooling systems (liquid cooling or phase-change materials) to improve heat dissipation during high-power charging.

## ADVANTAGES

- **Enhanced Battery Lifespan:**  
By monitoring and balancing individual cells, a BMS prevents overcharge, over-discharge, and thermal runaway, significantly extending the overall life of the battery pack.

- **Cost Savings:**

By prolonging battery life and reducing maintenance requirements, BMS solutions help lower the total cost of ownership. Enhanced safety and reliability reduce the risks and expenses associated with battery failures.

## LIMITATION

- **Initial Cost:** The integrated on-board charger and advanced BMS increase the overall vehicle cost due to additional sensors, control circuits, protection components, and communication modules.
- **System Complexity:** The design involves multiple sensing, control, and protection

circuits, making hardware design and troubleshooting more complex compared to conventional charging systems.

- **Thermal Management Challenges:** High-power charging generates heat, requiring efficient cooling systems. Inadequate thermal management may affect battery performance and lifespan.
- **Dependence on Electronics:** The system heavily relies on microcontrollers and semiconductor devices; failure of critical components may temporarily disable charging or vehicle operation.
- **Connectivity Limitations:** If IoT-based monitoring is implemented, the system depends on network availability (Wi-Fi, GSM, etc.). In areas with poor connectivity, real-time monitoring and remote diagnostics may be limited.
- **Power Quality Sensitivity:** The on-board charger performance may be affected by fluctuations in AC supply voltage, requiring additional protection and filtering circuits.

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