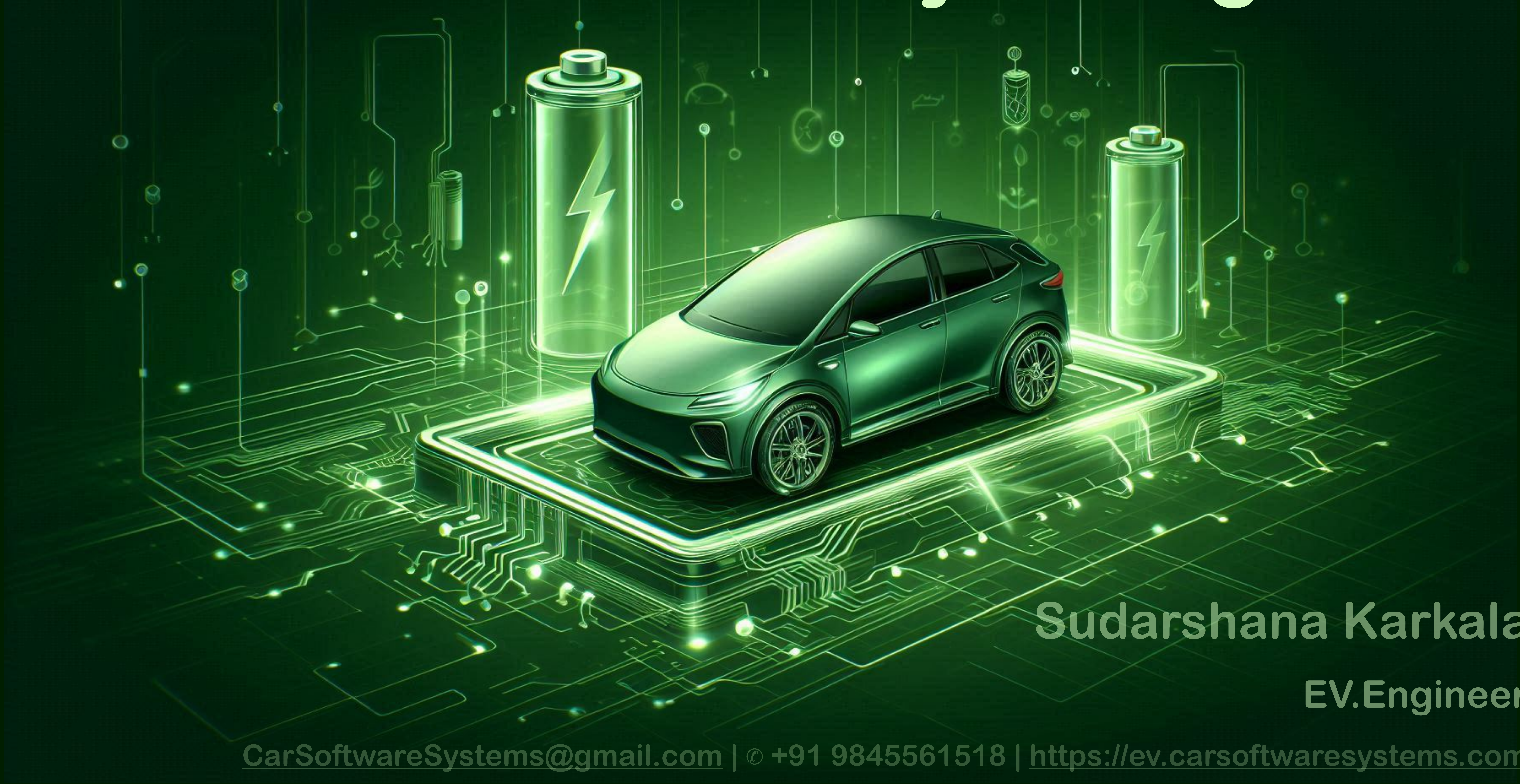
Electric Vehicle Battery Management



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Topics

- Battery Management Systems
- Architectural Design for Software Development
- Implementation details
- Testing and QA
- Reference
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Main Components of an Electric Vehicle

- Battery Pack
- Controller
- Electric Motor
- Battery Management Systems
- Battery (Aux)
- AC-DC Converter
- Drive Train
- Charge Point
- Thermal System
- Sensors
- Infotainments
- Air Conditioning
- .....

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BMS - Battery Management Systems

A **BMS** in an electric vehicle (EV) is an essential electronic system that ensures the safe, efficient, and reliable operation of the battery pack. The BMS monitors, manages, and protects the battery cells to optimise their performance and longevity while ensuring the vehicle operates safely.

Key functions of BMS

- Monitoring
- Balancing
- Protection
- Energy management
- Communication
- Thermal management

Monitoring

- **Voltage :** Monitors the voltage of individual cells and the overall battery pack to ensure they remain within safe operating limits.
- **Temperature :** Tracks the temperature of the battery to prevent overheating or overcooling, which can damage the cells.
- **Current :** Measures the charge and discharge currents to avoid overcurrent conditions.
- **State of Charge (SoC) :** Calculates how much charge is left in the battery.
- **State of Health (SoH) :** Assesses the overall health and capacity of the battery over time.

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Balancing

- Ensures that all cells in the battery pack are charged and discharged evenly to prevent overcharging or deep discharging of any individual cell, which can degrade performance or cause safety issues.
- Implements either active balancing (redistributing energy between cells) or passive balancing (dissipating excess energy as heat).

Protection

- Prevents unsafe operating conditions such as over-voltage, under-voltage, overcurrent, short circuits, and thermal runaway. Disconnects the battery pack from the system when critical faults occur.

Energy Management

- Optimises energy usage to extend the driving range of the EV.
- Helps in regenerative braking to recover energy efficiently.

Logging and Communication

- Interfaces with the EV's onboard systems (e.g., motor controller, thermal management system, and vehicle control unit) to exchange data and ensure coordinated operation.
- Uses communication protocols like CAN bus, LIN, or UART for real-time data exchange.

Thermal Management

- Works with the thermal management system to maintain optimal operating temperatures, often using cooling systems (air or liquid) or heaters.

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Why is a BMS Critical in EVs?

- **Safety :** Lithium-ion batteries, commonly used in EVs, are sensitive to voltage, temperature, and current. Without a BMS, there's a risk of fire, explosion, or other hazards.
- **Battery Life:** Proper monitoring and balancing prevent premature degradation of battery cells.
- **Performance:** The BMS ensures consistent and efficient power delivery for optimal vehicle performance.
- **Energy Efficiency:** Accurate SoC and SoH estimation helps drivers maximise the range of their EV.

Components of a BMS:

- **Sensors :** To measure voltage, current, and temperature.
- **Control Unit :** The "brain" that processes data and makes decisions based on pre-programmed algorithms.
- **Balancing Circuitry :** For equalising cell voltages.
- **Communication Interfaces :** For data exchange with other vehicle systems.

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Functions of BMS

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Functional Requirements

- Monitor voltage, current, and temperature of individual cells and the entire battery pack.
- Calculate State of Charge (SoC) and State of Health (SoH)
- Perform cell balancing to ensure uniform charge distribution.
- Detect and respond to faults (e.g., over-voltage, under-voltage, over-current, and thermal anomalies).
- Communicate with other vehicle systems via CAN bus.
- Log critical events for diagnostics and reporting

Non-Functional Requirements

- Real-time operation with response times < 100 ms
- Fail-safe mechanisms to handle critical faults.
- Scalable design to support different battery configurations.
- High reliability with an uptime of 99.99%.
- Compliance with safety standards (e.g., ISO 26262).
- [TO BE DONE]

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Components and Subsystems

Monitoring Module
(Voltage, temperature, and current sensing)

State Estimation Module
(SoC and SoH calculation algorithms)

Balancing Module
(Active or passive cell balancing logic)

Communication Module
(CAN protocol for data exchange with other systems)

Fault Detection and Management Module
(Monitors for fault conditions and triggers protective actions)

Layered Architecture

Application Layer	Includes SoC/SoH estimation, fault management, and cell balancing logic.
Middleware Layer	Handles communication protocols, data abstraction, and hardware interface drivers.
Hardware Abstraction Layer	Interfaces with sensors, ADCs, and actuators.

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Modules and Interfaces

Monitoring Module

Inputs : Sensor data (voltage, current, temperature).

Outputs : Processed data for SoC/SoH estimation and fault detection.

Balancing Module

Inputs: Voltage data from the monitoring module.

Outputs: Balancing commands to the hardware.

State Estimation Module

Inputs: Monitoring module data.

Algorithm : Kalman filter or equivalent model-based approach.

Outputs : SoC and SoH values.

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Courtesy | Reference

- https://nptel.ac.in/courses/108106182
- https://www.cavliwireless.com/blog/nerdiest-of-things/battery-management-system-in-electric-vehicles.html

Q & A

Thank you

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