Training Course on Battery Management Systems (BMS) for EVs

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This specialized training course provides a comprehensive deep dive into Battery Management Systems (BMS) for Electric Vehicles (EVs), equipping participants with the critical knowledge and practical skills required to design, develop, and validate these indispensable components of modern EVs. Training Course on Battery Management Systems (BMS) for EVs meticulously covers the entire spectrum of BMS functionalities, from cell monitoring, State-of-Charge (SoC) and State-of-Health (SoH) estimation, and cell balancing to thermal management, fault detection, and crucial safety protocols (ISO 26262). Attendees will gain hands-on expertise with industry-standard algorithms, simulation tools, and hardware considerations, understanding how BMS orchestrates the safe, efficient, and reliable operation of high-voltage battery packs. This course is essential for electrical engineers, automotive engineers, and battery specialists aiming to excel in the rapidly expanding electromobility sector.

The program emphasizes practical implementation and industry best practices, exploring trending topics such as advanced SoC/SoH/SoP estimation algorithms (e.g., Extended Kalman Filters, Neural Networks), second-life battery applications, wireless BMS architectures, cybersecurity for BMS, and integration with vehicle-to-grid (V2G) systems. Participants will delve into the intricacies of hardware-in-the-loop (HIL) testing, diagnostic communication protocols (CAN, LIN), and robust design for extreme operating conditions. By the end of this course, attendees will possess the expertise to architect, analyze, and optimize advanced BMS solutions, ensuring extended battery lifespan, enhanced vehicle performance, stringent safety compliance, and reduced warranty claims. This training is indispensable for professionals driving innovation and reliability in the electric vehicle and energy storage industries.

Programme Curriculum

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Course duration

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Course Objectives

1. Understand the fundamental architecture and critical functions of Battery Management Systems (BMS) in EVs.
2. Master various cell monitoring techniques for voltage, current, and temperature.
3. Implement and compare State-of-Charge (SoC) estimation algorithms (Coulomb Counting, Kalman Filters).
4. Develop and validate State-of-Health (SoH) and State-of-Power (SoP) estimation methodologies.
5. Design and apply active and passive cell balancing strategies for battery pack longevity.
6. Understand and implement thermal management strategies for optimal battery performance and safety.
7. Design fault detection, isolation, and diagnostic (FDID) mechanisms for battery pack anomalies.
8. Comprehend and apply functional safety principles (ISO 26262) in BMS design.
9. Integrate BMS with vehicle communication networks (CAN, LIN, Ethernet).
10. Explore advanced algorithms leveraging AI/ML for enhanced SoC/SoH estimation and predictive analytics.
11. Perform hardware-in-the-loop (HIL) testing and validation of BMS functionalities.
12. Address cybersecurity vulnerabilities and mitigation strategies for BMS.

13. Understand wireless BMS architectures and their advantages/challenges.

Organizational Benefits

1. Enhanced safety and reliability of their electric vehicle battery packs.
2. Extended lifespan and performance of EV batteries, leading to reduced warranty costs.
3. Improved accuracy of battery state estimations (SoC, SoH, SoP), enabling better range prediction.
4. Faster development and validation cycles for new BMS solutions.
5. Reduced risk of battery-related incidents (e.g., thermal runaway).
6. Optimized energy utilization and efficiency of the EV powertrain.
7. Competitive advantage by deploying cutting-edge and robust BMS technology.
8. Compliance with stringent automotive safety standards (e.g., ISO 26262).
9. Lower overall cost of ownership for EVs due to improved battery health.
10. Development of in-house expertise in a critically important EV technology.

Target Participants

- Battery Engineers
- BMS Engineers
- Electrical Engineers
- Automotive Software/Hardware Engineers
- System Integration Engineers
- Test and Validation Engineers for EVs
- Researchers in Battery Technology and Electromobility

Course Outline

Module 1: Introduction to EV Batteries and BMS Role

- **EV Battery Types:** Lithium-ion chemistries (NMC, LFP, NCA), their characteristics and applications.
- **Battery Pack Architecture:** Cells, modules, pack assembly, series/parallel connections.
- **Role of BMS:** Safety, performance, longevity, communication.
- **High-Voltage Safety:** Basic principles of working with high-voltage DC in EVs.
- **Case Study:** Deconstructing the battery pack design of a popular EV (e.g., Chevrolet Bolt EV or BYD Blade Battery).

Module 2: BMS Architecture and Components

- **Centralized, Distributed, and Modular BMS Architectures:** Pros and cons.
- **Key BMS Hardware Components:** Microcontroller, ADCs, communication interfaces, power switches, current sensors.
- **Isolation and Protection Circuits:** High-voltage isolation, pre-charge, contactors, fuses.
- **Power Supply and Auxiliary Systems:** Low-voltage power for BMS operation.
- **Case Study:** Designing a conceptual block diagram for a modular BMS architecture for a multi-module battery pack.

Module 3: Cell Voltage and Temperature Monitoring

- **Voltage Measurement Techniques:** Accuracy, resolution, sampling rate.
- **Temperature Sensing:** Thermistors, RTDs, and placement strategies.
- **Data Acquisition Systems:** Analog-to-Digital Converters (ADCs) and multiplexing.
- **Measurement Accuracy and Noise Reduction:** Filtering techniques.
- **Case Study:** Evaluating the requirements for a cell voltage monitoring circuit to achieve ±1mV accuracy across 100 series cells.

Module 4: Current Sensing and Coulomb Counting

- **Current Sensor Technologies:** Shunts, Hall-effect sensors, fluxgate sensors.
- **Accuracy and Dynamic Range of Current Sensing:** Bidirectional measurement.
- **Coulomb Counting for SoC:** Principles, errors, and drift.
- **Initialization and Recalibration of SoC:** Addressing cumulative errors.
- **Case Study:** Implementing a Coulomb Counting algorithm in a simulated environment and analyzing its drift over time.

Module 5: State-of-Charge (SoC) Estimation Algorithms

- **Open Circuit Voltage (OCV) Method:** Lookup tables, advantages, limitations.
- **Kalman Filter Family (EKF, UKF):** Principles, application for dynamic SoC estimation.
- **Neural Network/Machine Learning Approaches for SoC:** Data-driven models.
- **Hybrid SoC Estimation:** Combining multiple methods for robustness.
- **Case Study:** Applying an Extended Kalman Filter (EKF) to estimate SoC of a battery cell model in Simulink.

Module 6: State-of-Health (SoH) and State-of-Power (SoP) Estimation

- **Definition of SoH:** Capacity fade, internal resistance increase.
- **SoH Estimation Methods:** Impedance spectroscopy, capacity measurement, model-based.
- **Definition of SoP:** Maximum charge/discharge power.
- **SoP Estimation:** Instantaneous power capability, thermal limits.
- **Case Study:** Developing an algorithm to estimate battery SoH based on cycles and discharge capacity.

Module 7: Cell Balancing Techniques

- **Purpose of Cell Balancing:** Mitigating cell voltage imbalance.
- **Passive Cell Balancing:** Resistor-based dissipation.
- **Active Cell Balancing:** Capacitor-based, inductor-based, DC-DC converter-based.
- **Balancing Control Strategies:** On-demand, continuous, top-balancing, bottom-balancing.
- **Case Study:** Designing a passive cell balancing circuit for a module of 4 Li-ion cells.

Module 8: Thermal Management for Battery Packs

- **Heat Generation in Batteries:** Ohmic losses, entropy changes.
- **Cooling Strategies:** Air cooling, liquid cooling (direct, indirect), refrigerant cooling.
- **Heating Strategies:** For cold weather performance and fast charging.
- **Thermal Runaway Prevention:** Role of BMS in monitoring and mitigation.
- **Case Study:** Analyzing the thermal performance of a battery module under fast charging conditions and proposing cooling improvements.

Module 9: Fault Detection, Isolation, and Diagnostics (FDID)

- **Types of Battery Faults:** Over-voltage, under-voltage, over-current, over-temperature, cell imbalance, short circuits.
- **FDID Algorithms:** Threshold-based, model-based, data-driven.
- **Fault Reporting and Logging:** Storing diagnostic trouble codes (DTCs).
- **Degradation Monitoring:** Identifying early signs of battery degradation.
- **Case Study:** Developing a fault detection algorithm for an over-current condition in a battery pack.

Module 10: Functional Safety (ISO 26262) for BMS

- **Introduction to ISO 26262:** Automotive functional safety standard.
- **Hazard Analysis and Risk Assessment (HARA):** Identifying battery-related hazards.
- **ASIL Determination:** Assigning Safety Integrity Levels to BMS functions.
- **Safety Mechanisms:** Redundancy, self-tests, plausibility checks.
- **Case Study:** Performing a basic HARA for the high-voltage interlock system managed by the BMS.

Module 11: BMS Communication and Vehicle Integration

- **Communication Protocols:** CAN (Controller Area Network), LIN, Ethernet for automotive.
- **BMS to VCU Communication:** Data exchange for powertrain control.
- **BMS to Charger Communication:** Controlling charging process.
- **Diagnostic Communication:** UDS (Unified Diagnostic Services).
- **Case Study:** Defining the CAN communication matrix for data exchange between a BMS and a Vehicle Control Unit (VCU).

Module 12: Testing and Validation of BMS

- **Hardware-in-the-Loop (HIL) Testing:** Simulating battery and vehicle environments.
- **Software-in-the-Loop (SIL) Testing:** Early stage algorithm validation.
- **Component-Level Testing:** Cell balancing, current sensing accuracy.
- **System-Level Testing:** Pack-level performance, safety functions.
- **Case Study:** Designing a HIL test bench setup for validating BMS SoC estimation algorithms.

Module 13: Advanced BMS Algorithms and Trending Topics

- **AI/ML for BMS:** Predictive SoH, thermal runaway prediction, adaptive control.
- **Wireless BMS:** Advantages (wiring reduction, simplified assembly), challenges (reliability, security).
- **Second-Life Battery Management:** BMS adaptation for stationary energy storage.
- **Cybersecurity for BMS:** Threats (data manipulation, denial of service), mitigation.
- **Case Study:** Exploring the application of a small neural network for more accurate SoH prediction.

Module 14: BMS for Fast Charging and V2G/V2H

- **Impact of Fast Charging on BMS:** Thermal stress, degradation.
- **BMS Control for Fast Charging:** Optimizing charge profile.
- **Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H):** Bidirectional power flow.
- **BMS Role in V2G:** Managing grid services (frequency regulation, peak shaving).
- **Case Study:**

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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