Training Course on Electric Vehicle (EV) Powertrain Design

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 comprehensive training course on Electric Vehicle (EV) Powertrain Design offers a deep dive into the engineering principles and practical considerations for developing the core propulsion system of next-generation electric vehicles. Participants will gain expert-level understanding of all critical components, including electric motors, power electronics (inverters, converters), battery packs, battery management systems (BMS), and transmission systems. Training Course on Electric Vehicle (EV) Powertrain Design emphasizes a holistic, systems-level design approach, integrating aspects of energy efficiency, performance optimization, thermal management, and functional safety. Attendees will acquire hands-on experience with industry-standard simulation tools (e.g., MATLAB/Simulink, Ansys) and design methodologies, essential for shaping the future of sustainable mobility. This course is vital for automotive engineers, electrical engineers, and product developers eager to contribute to the rapidly evolving EV industry.

The program highlights cutting-edge advancements and industry best practices, exploring trending topics such as wide bandgap (WBG) power semiconductors (SiC, GaN), advanced motor control strategies (field-oriented control), second-life battery applications, vehicle-to-grid (V2G) integration, and the application of AI/ML for powertrain optimization and predictive maintenance. Participants will delve into the intricacies of NVH (Noise, Vibration, and Harshness) reduction, electromagnetic compatibility (EMC), and robust design for reliability and durability. By the end of this course, attendees will possess the expertise to design, analyze, and optimize high-performance, efficient, and safe EV powertrains, enabling them to lead innovation and overcome the complex engineering challenges in the burgeoning electromobility sector. This training empowers professionals to drive the transition towards a greener and more electric future.

Programme Curriculum

Training Course on Electric Vehicle (EV) Powertrain Design

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Course Objectives

1. Understand the fundamental architecture and components of various EV powertrains (BEV, HEV, PHEV).
2. Analyze and select appropriate electric motor technologies (PMSM, Induction, SRM) for specific EV applications.
3. Design and optimize power electronic converters (inverters, DC-DC) for high efficiency and power density.
4. Comprehend battery chemistry fundamentals, cell-to-pack integration, and thermal management strategies for EV batteries.
5. Implement Battery Management Systems (BMS) functionalities including SOC/SOH estimation and safety protocols.
6. Apply advanced motor control techniques such as Field-Oriented Control (FOC) for optimal performance.
7. Perform powertrain efficiency analysis across various drive cycles and operating conditions.
8. Utilize simulation tools (e.g., MATLAB/Simulink, Ansys) for comprehensive powertrain modeling and validation.
9. Address NVH (Noise, Vibration, and Harshness) challenges in EV powertrain design.
10. Understand electromagnetic compatibility (EMC) and EMI mitigation in high-power EV systems.
11. Design for functional safety (ISO 26262) principles in critical powertrain components.

12. Explore trending technologies like Wide Bandgap (WBG) semiconductors and AI/ML for powertrain optimization.
13. Integrate regenerative braking systems for enhanced energy recovery and efficiency.

Organizational Benefits

1. Accelerated R&D cycles for new EV models and powertrain innovations.
2. Reduced prototyping and testing costs through enhanced simulation capabilities.
3. Improved performance, range, and efficiency of their electric vehicle products.
4. Enhanced product reliability and safety, meeting stringent automotive standards.
5. Faster troubleshooting and diagnosis of powertrain-related issues.
6. Competitive advantage in the rapidly expanding global EV market.
7. Development of in-house expertise in critical EV powertrain technologies.
8. Optimization of supply chain decisions through better component understanding.
9. Compliance with evolving regulations related to EV performance and safety.
10. Contribution to sustainability goals by designing more energy-efficient and robust EVs.

Target Participants

- Automotive Engineers
- Electrical Engineers
- Mechanical Engineers
- Powertrain System Designers
- Battery Engineers
- Power Electronics Engineers
- Researchers and Developers in Electromobility
- Product Development Teams in the EV Industry

Course Outline

Module 1: Introduction to Electric Vehicle Architectures

- **EV Types and Topologies:** BEV, HEV, PHEV, FCEV, Series, Parallel, Series-Parallel configurations.
- **Key Powertrain Components Overview:** Motor, Inverter, Battery, BMS, Transmission, DCDC Converter.
- **Performance Metrics:** Range, Acceleration, Top Speed, Energy Consumption.
- **Drive Cycles and Their Impact:** WLTP, EPA, NEDC, FTP-75.
- **Case Study:** Analyzing the powertrain architecture and performance specifications of a popular production EV (e.g., Tesla Model 3 or Nissan Leaf).

Module 2: Electric Motors for EV Powertrains

- **Types of Electric Motors:** PMSM, Induction Motor, Switched Reluctance Motor (SRM), DC Motors.
- **Operating Principles and Characteristics:** Torque-speed curves, efficiency maps.
- **Motor Sizing and Selection:** Matching motor characteristics to vehicle requirements.
- **Thermal Management of Electric Motors:** Cooling strategies (air, liquid, oil).

- **Case Study:** Selecting the optimal motor type and size for a compact city EV based on performance requirements.

Module 3: Power Electronics: Inverters and Converters

- **Role of Power Electronics:** DC-AC Inverters, DC-DC Converters, On-Board Chargers.
- **Semiconductor Devices:** IGBTs, MOSFETs, and **Wide Bandgap (WBG) devices (SiC, GaN)**.
- **Inverter Topologies and Control:** H-bridge, multi-level inverters, PWM strategies.
- **DC-DC Converter Design:** Buck, Boost, Buck-Boost for auxiliary systems and voltage matching.
- **Case Study:** Designing an efficient inverter for a PMSM-based EV powertrain, considering switching losses and thermal performance.

Module 4: EV Battery Technology and Pack Design

- **Battery Chemistry Fundamentals:** Li-ion (NMC, LFP, NCA), solid-state batteries.
- **Cell to Module to Pack Integration:** Mechanical, electrical, thermal aspects.
- **Battery Sizing and Range Calculation:** Capacity, voltage, energy density.
- **Safety Considerations:** Thermal runaway, crash safety, short-circuit protection.
- **Case Study:** Designing a high-voltage battery pack for a long-range EV, including mechanical integration and safety features.

Module 5: Battery Management System (BMS)

- **BMS Functions:** Cell monitoring (voltage, temperature), State of Charge (SOC), State of Health (SOH) estimation.
- **Cell Balancing Techniques:** Passive and active balancing.
- **Fault Detection and Diagnostics:** Over-voltage, under-voltage, over-current, thermal faults.
- **Communication Protocols:** CAN bus, LIN bus for BMS data.
- **Case Study:** Developing an algorithm for accurate SOC estimation for an EV battery pack under varying driving conditions.

Module 6: Transmission Systems in EVs

- **Fixed Gear Ratio vs. Multi-Speed Transmissions:** Advantages and disadvantages.
- **Gearbox Design Considerations:** Efficiency, NVH, packaging.
- **Differential and Axle Integration:** Delivering power to wheels.
- **Reduction Gear Optimization:** Matching motor speed to wheel speed.
- **Case Study:** Evaluating the benefits of a 2-speed transmission versus a single-speed for an electric sports car to optimize acceleration and top speed.

Module 7: Powertrain Control and Software

- **Vehicle Control Unit (VCU) Architecture:** Centralized vs. Distributed control.
- **Motor Control Strategies:** Scalar control, Vector Control, **Field-Oriented Control (FOC)**.
- **Torque Coordination and Blending:** Electric motor and regenerative braking.
- **Software Development for Powertrains:** Embedded systems, functional safety (ISO 26262).
- **Case Study:** Implementing a basic FOC algorithm for an electric motor in a simulated environment.

Module 8: Thermal Management of EV Powertrains

- **Heat Sources in EVs:** Battery, Motor, Inverter, On-board Charger.
- **Cooling Strategies:** Air cooling, Liquid cooling, Refrigerant cooling.

- **Thermal Modeling and Simulation:** Predicting temperature distribution.
- **Integrated Thermal Management Systems:** Optimizing cooling for multiple components.
- **Case Study:** Designing a liquid cooling system for an EV battery pack to maintain optimal operating temperature and extend lifespan.

Module 9: Energy Management and Efficiency Optimization

- **Energy Flow Analysis:** Tracing energy losses throughout the powertrain.
- **Regenerative Braking Systems:** Maximizing energy recovery.
- **Auxiliary Load Management:** Optimizing power consumption of ancillary systems.
- **Range Extenders and Hybrid Strategies:** Enhancing overall efficiency.
- **Case Study:** Calculating the potential range extension from regenerative braking for a specific EV on a given drive cycle.

Module 10: Powertrain NVH and EMC Considerations

- **Noise, Vibration, and Harshness (NVH):** Sources (motor, gears), mitigation techniques.
- **Electromagnetic Compatibility (EMC):** Reducing EMI from power electronics.
- **Shielding and Filtering Techniques:** For both conducted and radiated emissions.
- **Compliance with EMC Standards:** Automotive standards (e.g., CISPR 25).
- **Case Study:** Identifying potential NVH issues in an electric motor design and proposing mitigation strategies.

Module 11: Powertrain Simulation and Modeling

- **System-Level Modeling:** Using tools like MATLAB/Simulink, AMESim.
- **Component-Level Modeling:** FEM for motors (Ansys Maxwell), CFD for thermal (Ansys Fluent).
- **Co-simulation Techniques:** Integrating different simulation domains.
- **Model-Based Design (MBD):** From concept to production.
- **Case Study:** Building a comprehensive MATLAB/Simulink model of an EV powertrain to predict vehicle performance and energy consumption.

Module 12: Functional Safety (ISO 26262) in Powertrain Design

- **Introduction to ISO 26262:** Automotive functional safety standard.
- **Hazard Analysis and Risk Assessment (HARA):** Identifying safety goals.
- **ASIL Determination:** Assigning Automotive Safety Integrity Levels.
- **Safety Mechanisms and Validation:** Ensuring critical functions are safe.
- **Case Study:** Conducting a basic HARA for the high-voltage battery system of an EV powertrain.

Module 13: Charging Systems and Vehicle-to-Grid (V2G)

- **Charging Standards:** Type 1, Type 2, CCS, CHAdeMO, GB/T.
- **AC vs. DC Charging:** On-board vs. Off-board chargers.
- **V2G and V2H Concepts:** Bidirectional power flow, grid services.
- **Smart Charging and Grid Integration:** Managing charging demand.
- **Case Study:** Analyzing the potential benefits and challenges of integrating an EV fleet with a smart grid using V2G technology.

Module 14: Manufacturing, Testing, and Validation

- **Manufacturing Processes for EV Components:** Motors, batteries, inverters.
- **End-of-Line Testing:** Functional and performance testing of powertrains.

- **Durability and Reliability Testing:** Accelerated life testing.
- 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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