Training Course on Power Electronics for EV and HEV Applications

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 Power Electronics for EV and HEV Applications provides an in-depth understanding of the foundational principles and cutting-edge technologies that drive the electrification of modern vehicles. Participants will delve into the design, analysis, and control of various power electronic converters crucial for Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs). Training Course on Power Electronics for EV and HEV Applications meticulously covers DC-DC converters, AC-DC rectifiers, DC-AC inverters, and battery chargers, with a strong emphasis on high-efficiency design, power density optimization, thermal management, and robust control strategies. Attendees will gain hands-on expertise with industry-standard simulation tools (e.g., MATLAB/Simulink, PSIM, LTSpice) and learn to select and apply advanced power semiconductor devices like SiC and GaN. This course is essential for electrical engineers, automotive engineers, and power electronics specialists seeking to master the core technological enablers of sustainable transportation.

The program emphasizes practical considerations and addresses trending topics in the field, including bidirectional power flow for V2G applications, fault-tolerant converter designs, electromagnetic compatibility (EMC) in high-power switching systems, and the integration of AI/ML for predictive control and diagnostics of power electronic components. Participants will explore the intricate trade-offs between efficiency, cost, size, and reliability, and learn to optimize these factors for various EV/HEV powertrain architectures. By the end of this course, attendees will possess the expertise to design, simulate, and analyze high-performance power electronic systems for electric and hybrid vehicles, enabling them to lead innovation in electromobility, energy conversion, and advanced automotive power management. This training is indispensable for professionals driving the development of cleaner, more efficient, and intelligent vehicle propulsion systems.

Programme Curriculum

Training Course on Power Electronics for EV and HEV Applications

Introduction

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Course Objectives

1. Understand the fundamental role and classification of power electronic converters in EV and HEV powertrains.
2. Analyze and design various DC-DC converter topologies (Buck, Boost, Buck-Boost, Isolated) for EV/HEV applications.
3. Comprehend the operation and control of DC-AC inverters for electric motor drives.
4. Apply Pulse Width Modulation (PWM) techniques for efficient converter control.
5. Select and characterize power semiconductor devices, including Wide Bandgap (WBG) materials like SiC and GaN.
6. Perform efficiency analysis and loss calculation for power electronic converters.
7. Design effective thermal management solutions for high-power density converters.
8. Understand on-board and off-board EV battery charging systems and their topologies.
9. Address electromagnetic compatibility (EMC) and EMI mitigation in power electronic circuits.
10. Utilize simulation tools (e.g., MATLAB/Simulink, PSIM) for power converter design and validation.
11. Explore bidirectional power flow control for Vehicle-to-Grid (V2G) and Vehicle-to-Load (V2L) applications.

12. Comprehend functional safety (ISO 26262) considerations for critical power electronic components.
13. Integrate AI/ML techniques for intelligent control, diagnostics, and optimization of power converters.

Organizational Benefits

1. Accelerated design and development cycles for EV/HEV power electronic systems.
2. Improved efficiency and power density of their vehicle electrification products.
3. Reduced prototyping and testing costs through enhanced simulation and design capabilities.
4. Enhanced product reliability and lifetime through robust design and thermal management.
5. Faster troubleshooting and diagnosis of power electronics-related issues.
6. Competitive advantage by adopting cutting-edge WBG semiconductor technologies.
7. Development of in-house expertise in a critically important EV/HEV technology.
8. Compliance with stringent automotive standards (e.g., functional safety, EMC).
9. Exploration of new functionalities like V2G for added value and revenue streams.
10. Contribution to sustainability goals by developing more energy-efficient vehicle components.

Target Participants

- Power Electronics Engineers
- Electrical Engineers
- Automotive Engineers
- Powertrain System Designers
- Control System Engineers
- Battery Charging System Designers
- Researchers and Developers in Electromobility

Course Outline

Module 1: Introduction to EV/HEV Powertrain and Power Electronics Role

- **EV/HEV Architectures:** BEV, HEV (Series, Parallel, Series-Parallel), PHEV.
- **Role of Power Electronics:** Interfacing battery, motor, charger, and auxiliary loads.
- **Key Power Electronic Converters:** DC-DC, Inverters, Rectifiers, Chargers.
- **Power Semiconductor Devices Overview:** Diodes, MOSFETs, IGBTs.
- **Case Study:** Identifying the primary power electronic components in a modern HEV powertrain diagram.

Module 2: DC-DC Converters for EV/HEV

- **Non-Isolated Converters:** Buck, Boost, Buck-Boost topologies and operation.
- **Isolated Converters:** Flyback, Forward, Full-Bridge, LLC resonant converters.
- **Applications:** Battery voltage adaptation, auxiliary power supply (12V/48V), fuel cell integration.
- **Control Strategies:** PWM control, voltage/current mode control.
- **Case Study:** Designing a bidirectional DC-DC converter for voltage matching between a 400V battery pack and a 600V motor inverter bus.

Module 3: DC-AC Inverters for Electric Motor Drives

- **Inverter Topologies:** Half-bridge, Full-bridge, 3-phase bridge.
- **Modulation Techniques:** Sine PWM (SPWM), Space Vector PWM (SVPWM).
- **Inverter Control for Motors:** V/f control, Field-Oriented Control (FOC) principles.
- **Harmonic Distortion and Filtering:** Mitigating unwanted harmonics.
- **Case Study:** Simulating a 3-phase inverter driving a Permanent Magnet Synchronous Motor (PMSM) using SVPWM in a simulation tool.

Module 4: AC-DC Rectifiers for On-Board Charging

- **Uncontrolled Rectifiers:** Diode bridge rectifiers.
- **Controlled Rectifiers:** Thyristor-based, PWM rectifiers (bi-directional).
- **Power Factor Correction (PFC):** Active and passive PFC circuits.
- **Harmonic Standards:** IEEE 519, IEC 61000-3-2.
- **Case Study:** Designing an active PFC circuit for an on-board EV charger to meet harmonic current limits.

Module 5: EV/HEV Battery Charging Systems

- **On-Board Chargers (OBC):** AC-DC conversion within the vehicle.
- **Off-Board DC Fast Chargers (DCFC):** High power, external rectifiers.
- **Charging Topologies:** Resonant converters, interleaved converters.
- **Communication Protocols:** CAN, PLC (Power Line Communication) for charging.
- **Case Study:** Analyzing the power stage design of a 22 kW on-board charger.

Module 6: Advanced Power Semiconductor Devices

- **Silicon (Si) Devices:** MOSFETs, IGBTs – characteristics and limitations.
- **Wide Bandgap (WBG) Semiconductors: Silicon Carbide (SiC) and Gallium Nitride (GaN)**.
- **Advantages of WBG:** Higher efficiency, higher switching frequency, higher temperature operation.
- **Gate Driver Design:** Requirements for driving SiC/GaN devices.
- **Case Study:** Comparing the efficiency benefits of using SiC MOSFETs vs. Si IGBTs in a high-voltage inverter.

Module 7: Efficiency Analysis and Loss Calculation

- **Types of Losses:** Conduction losses, switching losses, gate losses.
- **Loss Models for Semiconductors:** Analytical and empirical models.
- **Measurement Techniques for Efficiency:** Calorimetric, power analyzer.
- **Efficiency Mapping:** Performance across operating ranges.
- **Case Study:** Calculating the total power losses of a DC-DC converter under different load conditions.

Module 8: Thermal Management of Power Electronic Converters

- **Heat Generation Sources:** Semiconductor devices, inductors, capacitors.
- **Thermal Resistance Networks:** Junction-to-case, case-to-sink.
- **Cooling Techniques:** Air cooling, liquid cooling, heat pipes.
- **Thermal Modeling and Simulation:** CFD for heat sink design.
- **Case Study:** Designing a heatsink for an inverter power module to keep junction temperatures within limits.

Module 9: Electromagnetic Compatibility (EMC) and EMI Mitigation

- **Sources of EMI in Power Electronics:** High dv/dt, di/dt, switching transients.
- **Conducted vs. Radiated EMI:** Standards (CISPR 25, IEC 61000).
- **Mitigation Techniques:** Filtering (common mode, differential mode), shielding, grounding.
- **Layout Considerations:** Minimizing loop areas, optimizing gate drive paths.
- **Case Study:** Identifying potential EMI issues in a high-frequency DC-DC converter and proposing filtering solutions.

Module 10: Control Strategies for Power Converters

- **Analog vs. Digital Control:** Advantages and limitations.
- **PWM Techniques Review:** SPWM, SVPWM.
- **Current Mode Control vs. Voltage Mode Control:** Stability and response.
- **Digital Control Implementation:** DSPs, Microcontrollers, FPGAs.
- **Case Study:** Implementing a digital current control loop for a boost converter using a microcontroller.

Module 11: Simulation and Modeling of Power Electronic Systems

- **Circuit Simulators:** SPICE, LTSpice, PSIM for component-level analysis.
- **System-Level Simulators:** MATLAB/Simulink, Ansys Twin Builder.
- **Hardware-in-the-Loop (HIL) Simulation:** Real-time testing of control algorithms.
- **Model-Based Design (MBD) Workflow:** From concept to code generation.
- **Case Study:** Building a Simulink model of an EV traction inverter and motor, and simulating its dynamic response.

Module 12: Bidirectional Power Flow (V2G/V2L)

- **Bidirectional Converter Topologies:** Dual Active Bridge (DAB), NPC, Vienna Rectifier.
- **Control for Bidirectional Power:** Seamless transition between charging/discharging.
- **Vehicle-to-Grid (V2G) Services:** Peak shaving, frequency regulation, voltage support.
- **Vehicle-to-Load (V2L) Applications:** Powering external devices.
- **Case Study:** Designing a control strategy for a bidirectional on-board charger enabling V2G functionality.

Module 13: Functional Safety (ISO 26262) for Power Electronics

- **Introduction to ISO 26262:** Automotive functional safety standard.
- **Hazard Analysis and Risk Assessment (HARA):** Identifying power electronics-related hazards.
- **ASIL Determination:** Assigning Automotive Safety Integrity Levels.
- **Safety Mechanisms and Validation:** Redundancy, diagnostics, monitoring.
- **Case Study:** Performing a basic HARA for a high-voltage DC-DC converter in an EV powertrain.

Module 14: Fault Tolerance and Diagnostics

- **Common Faults:** Open-circuit, short-circuit in semiconductors, sensor failures.
- **Fault Detection Techniques:** Current/voltage monitoring, signal processing.
- **Fault Isolation and Reconfiguration:** Maintaining operation despite faults.
- **Predictive Maintenance with AI/ML:** Monitoring component health.
- Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
16 Nov 2026	27 Nov 2026	Online	$2,000
16 Nov 2026	27 Nov 2026	Physical	$3,000
16 Nov 2026	27 Nov 2026	Physical	$6,000
16 Nov 2026	27 Nov 2026	Physical	$6,000
16 Nov 2026	27 Nov 2026	Physical	$12,000
16 Nov 2026	27 Nov 2026	Physical	$9,000
16 Nov 2026	27 Nov 2026	Physical	$12,000
16 Nov 2026	27 Nov 2026	Physical	$12,000

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