



Electric Vehicle Powertrain Engineering

Course: E-Motors, Inverters, BMS and Thermal Management



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Introduction:

Electric vehicle powertrain engineering, covering e-motors, inverters, BMS and thermal management, is a 5-day course for powertrain, power electronics, battery system and validation engineers that ends with a Powertrain Specification and Validation Plan for a case vehicle programme. Vehicle makers and suppliers lose range, cost and launch time when motor, inverter, pack and cooling loop are sized separately and meet for the first time on the dynamometer. Nominees already work on vehicle or component development, and each day builds sizing, control and thermal models in spreadsheets. CoreConcept Training Center delivers this electric vehicle powertrain engineering course.

Course Objectives:

- Derive traction torque, power and energy targets from a drive cycle, vehicle mass, road load and gradeability requirement
- Select and size a traction motor topology among permanent magnet synchronous, induction, wound-field synchronous and switched reluctance machines
- Specify a traction inverter, including silicon carbide or IGBT switch choice, field-oriented control loops and loss estimates on an efficiency map
- Define battery management functions for state of charge and state of health estimation, cell balancing, current limits and contactor sequencing
- Design a pack and drive-unit cooling concept that holds cell and junction temperatures within limits during fast charging and sustained load
- Plan powertrain integration and verification through hazard analysis to ISO 26262, dynamometer and hardware-in-the-loop tests and EMC checks

Target Audience:

- Powertrain system engineering teams responsible for vehicle-level energy, torque and range targets
 - Electric machine and power electronics design teams responsible for motor and inverter specifications
 - Battery system and BMS engineering teams responsible for pack functions, estimation algorithms and protection logic
 - Thermal and vehicle integration teams responsible for cooling circuits, packaging and component interfaces
 - Validation and functional safety teams responsible for test plans, safety goals and release evidence
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Course Outline:

Day 1: Vehicle Requirements and Electric Drive Architecture Choices

- Drive Cycle Analysis for Wheel Torque and Power Demand
- Road Load Equation With Rolling, Aerodynamic and Grade Terms
- Single, Dual and Axle-Split Motor Architecture Trade Study
- Reduction Gear Ratio Selection Against Top Speed and Launch
- Energy Consumption Budget per Kilometre and Range Target Cascade

Day 2: Traction Motor Topologies and Inverter Power Stage Design

- Interior Permanent Magnet Synchronous Machine Torque Production and Saliency
- Induction, Wound-Field and Switched Reluctance Machines Compared on Rare-Earth Exposure
- Motor Efficiency Map Construction Across Torque-Speed Operating Points
- Silicon Carbide Versus IGBT Power Module Conduction and Switching Losses
- DC-Link Capacitor Sizing and Busbar Stray Inductance Limits

Day 3: Motor Control, BMS Functions and Charging Interfaces

- Field-Oriented Control With Maximum Torque per Ampere and Field Weakening
- Coulomb Counting and Kalman Filter State of Charge Estimation
- State of Health and State of Power Derating Limits
- Passive Versus Active Cell Balancing Circuit Selection
- IEC 62196 Coupler, On-Board Charger and DC Fast-Charge Handshake

Day 4: Thermal Management, Functional Safety and Failure Cases

- Cold Plate and Coolant Loop Sizing for Pack Heat Rejection
- Heat Pump and Chiller Integration for Cabin and Battery
- Fast-Charge Thermal Envelope and Lithium Plating Avoidance Limits
- ISO 26262 Hazard Analysis, ASIL Assignment and Powertrain Safety Goals
- ISO 6469 Electrical Protection, Insulation Monitoring and Contactor Weld Detection

Day 5: Modelling Build: Powertrain Specification and Validation Plan

- Case Vehicle Requirement Sheet and Motor-Inverter Sizing Model
 - Case Pack Energy, BMS Function List and Cooling Duty Calculation
 - Hardware-in-the-Loop and Motor Dynamometer Test Matrix Build
 - EMC, Durability and Fault-Injection Test Case Allocation
 - Powertrain Specification and Validation Plan Completion and Design Review
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Skills You Will Gain:

- Drive Cycle Requirement Derivation
- Traction Motor Sizing
- Inverter Loss Estimation
- Field-Oriented Control Tuning
- Battery State Estimation
- Pack Thermal Design
- Automotive Hazard Analysis
- Powertrain Test Planning

Why Attend This Course:

- Deliver a Powertrain Specification and Validation Plan for a case vehicle programme to the chief engineer and the powertrain release board
- Choose a motor topology, switch technology and cooling concept from modelled losses, temperatures and cost rather than supplier preference
- Prevent late redesigns, failed thermal tests and missing safety evidence that push back vehicle launch and add warranty exposure
- Hand over sizing spreadsheets, BMS function lists and test matrices that design and validation colleagues can reuse on the next platform

Conclusion:

Back at work, the participant gives the chief engineer and the powertrain release board a Powertrain Specification and Validation Plan that sets torque, power and energy targets, motor and inverter choices, BMS functions, cooling duty, safety goals and the test matrix. The board uses it to freeze the component specifications sent to suppliers and to approve test rig time. After the first prototype round on the dynamometer, the team should compare measured efficiency, temperatures and fault responses with the plan and update the sizing models.

Frequently Asked Questions FAQ:

What should participants know before an electric vehicle powertrain engineering course?

Participants should hold an engineering degree or equivalent experience in vehicle, electrical or control design and be comfortable with spreadsheets. Basic knowledge of three-phase machines and DC circuits helps. A laptop is used for the sizing, efficiency and thermal models built each day.

How does electric vehicle powertrain engineering differ from an EV maintenance or battery cell production course?

Electric vehicle powertrain engineering specifies and integrates motors, inverters, BMS and cooling during product development. Maintenance courses isolate and repair vehicles already in service, and cell production courses run coating, assembly and formation lines in a battery plant.

Why does electric vehicle powertrain engineering treat thermal management as a design input?

Motor magnets, power switches and cells all lose performance or life above their temperature limits, so cooling capacity decides continuous power, fast-charge time and durability. Sizing the cooling loop with the motor, inverter and pack avoids late derating and redesign.

What do participants take back from the electric vehicle powertrain engineering course?

Participants take back a Powertrain Specification and Validation Plan for a case vehicle programme, with a requirement sheet, motor-inverter sizing model, BMS function list, cooling duty calculation, hazard analysis and a test matrix for dynamometer, hardware-in-the-loop and EMC work.
