AR&D

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Hybrid Electric Vehicle Systems
5-Day Course

One of the fastest growing automotive fields, hybrid electric vehicles (HEV) provides both opportunities and challenges to automotive instructors and technicians. The HEV technology is more fuel efficient and environmentally friendly compared to conventional vehicles. Optimizing the power intake in HEVs permits the engine operation to be maintained within the best fuel economy and less emission; while the electric machine (motor/generator) system provides additional propulsion electrical power input or generates electrical power through kinetic energy from regenerative braking or from the engine. These advantages have attracted worldwide development interests for HEVs in the automotive instruction and repair industries. The Toyota Prius occupies approximately 52% of the market while other hybrid models continue to grow. Experts predict that HEVs will own at least 6% of the total vehicle market by year 2012. As a result, this could affect more than 200,000 jobs within the numerous automotive related industries.

This extensive combination “lecture & hands-on” 5-day course will cover the fundamentals and advanced electric propulsion concepts, blending traditional engine and electric propulsion torque, system design, basic and enhanced diagnostic considerations, and special service topics of HEVs. In an easy to understand format, this course will explain safety and electric propulsion systems including the construction, operation, control strategies, service tools, scan tool data, and basic diagnostic fundamentals. Also included will be the discussion and use of oscilloscopes, current probes, differential scope probes, electric machine test equipment, and specific scan tool PIDs to be used to support hands-on exercises for enhanced analysis and diagnostics.

***Special Note**: This 5-day course provides over 2 days dedicated to performing hands-on exercises and covering engineering based information which further reinforces the hybrid systems operational and diagnostic concepts.*

Existing HEV production vehicle architectures from Ford, Honda, Lexus, Toyota, and GM will be used as case studies.

Course Materials for all attendees will include:

- Volume 1 HEVPS Student Book
- TTT Worksheets/Course Handouts/Hybrid Calculator (on CD), and Attaché

Benefits of Attending

This seminar is designed for attendees that are automotive (and electrical) technicians, or automotive students in advanced studies.

Upon completion of this seminar you will be able to:

- ✓ Describe the operation and determine the functionality of:
    - 3-Phase ac induction and permanent magnet electric machine systems (motors/generators)
    - 3-Phase Power Inverter systems
    - Power electronics sensor systems
    - Regenerative braking
    - Battery Pack and Energy Management systems
    - Hybrid engine mechanical and operational overview
    - Electric propulsion operation as a system
    - Hybrid vehicle safety systems
    - High Voltage electrical safety precautions
    - dc-dc Converter systems
    - Isolation fault detection systems
    - High Voltage Interlock systems
    - High Voltage service switch systems
    - Hybrid jump starting and jump start assist procedures
    - Hybrid operating modes
    - Scan tool data and device controls
    - Utilize Electrical equations and calculations to more thoroughly understand system design and functionality
- ✓ Instructor Demonstrations and Participant Hands-On Exercises will reinforce the information provided during this course
- ✓ Apply newly acquired knowledge to OEM service information
- ✓ Safely disable HEV high voltage systems to perform repairs
- ✓ Identify the various types of HEV safety systems
- ✓ Utilize scan tool data to analyze an HEV system for proper operation
- ✓ Develop strategies and skills for analyzing, diagnosing and repairing HEV systems
- ✓ Purchase and use the correct type of tools equipment to safely analyze and diagnose an HEV power system
- ✓ Advise students, colleagues, or customers on all aspects of HEV systems
- ✓ Confidently begin your career in the instruction, diagnostics and/or repair of HEV systems

Seminar Content

Ford, General Motors, Honda, Lexus, and Toyota Hybrid systems will be featured to explain the following topics:

- Current and future manufacturer hybrid programs (2001 – 2012)
- Introduction to HEV Technology (High Voltage and 42V Systems)
- Hybrid Engine Operation
    - The use of Atkinson-Miller Cycle Operation with Electric Traction Systems
- High Voltage Safety
- 3-Phase Induction and Permanent Magnet Electric Machines
- 3-Phase Power Inverter Systems
- 3-Phase Power Inverter Sensor Systems
- 3-Phase Power Inverter Thermal Systems
- Electric Propulsion Control Systems
- Active and Passive High Voltage Bus Discharge Systems
- Vehicle high Voltage Safety systems
- Collision Systems and High Voltage Safety Systems
- High Voltage Personal Protection Systems and Tools
- dc-dc Converter Systems
- Hybrid Braking Systems
- Electric Propulsion Operating Modes
- Battery Pack and Energy Management Systems
- Pre-Charge Systems
- Battery Pack Thermal Systems
- Service Switch/Manual High Voltage Disconnect Systems
- Nickel Metal Hydride Battery Technology
- Battery Pack Control Systems
- High Voltage Isolation Fault Detection Systems
- High Voltage Interlock Systems
- HEV Jump Starting and Jump Start Assist Systems and Procedures
- HEV Climate Control Systems (Air Conditioning & Cabin Heating Systems)
- Automatic Transmissions and HEV Operation

Listed below is an additional overview of the topics covered in this seminar course. Although a thorough instruction of all current HEV propulsion systems is provided in this seminar, systems soon to be released by numerous manufacturers will also be discussed and analyzed for operation, diagnostics and servicing.

Hybrid and Electric Vehicles:

- Introduction to hybrid technology
- Hybrid technology, what it is, and the differences between each technology
- Hybrid powertrain designs:
  - Series
  - Parallel
  - Series-parallel
- Discover that all hybrid systems utilize common system strategies and components and learning these fundamentals will permit you to advance and study any manufacturers system. In our seminars we not only instruct these fundamentals but we weave strategic hybrid manufacturer information into the course to cement course concepts. The major technical areas, instructor demonstrations, and hands-on exercises included in this course are as follows:

3-Phase Induction and Permanent Magnet Motors:

- **Construction**
  - Stator, Rotor, Gearing/Differentials, Sensors, Cooling Systems, and more.
  - Permanent magnet rotor design with “bread loaf”, rectangular, and “V” shaped magnets….and the differences of each type
  - Induction motor aluminum and copper rotor designs, shorting rings, and the laminations
- **Operating Principles**
  - Review and learn about Magnetism, Poles, Speed, Torque, Stator Frequency, Regenerative Braking, Slip (Negative, Positive, and Zero Slip), Traction Control.....
  - Learn the difference between Vector and Slip Motor Control strategies
  - Learn how Motor Speed and Torque are created
  - Systems can be either speed or torque controlled systems….understand why automotive systems are torque controlled and not speed controlled systems
  - How Induction and Permanent Magnet motors rotate without using any contacting components
  - Learn how the number of Motor Poles and Stator Frequency controls maximum Motor Speed
  - Discover how the Induction and Permanent Magnet motors are used to recharge the batteries when the vehicle coasts and how this energy is generated and controlled
  - Learn how some hybrid generators not only supply electrical power but also control the gear ratio of the transmission

dc-dc Converters:

- Discover how the dc-dc converter reduces the 300-400 Volts from the Battery Pack to just 14.5 Volts to charge a 12 Volt battery
- Discover how the dc-dc converter boosts 14.5 Volts from the 12 Volt Battery to 300-400 Volts
- Learn why the dc-dc converter replaces the traditional generator (alternator)
- Learn the control strategies of how these converters control high voltage electrical power and convert it to a 14.5 volt level
- Study the design of the converter to understand its similarities and differences with the traditional vehicle generator
- Study how battery pack systems utilize an internal charging system to recover the battery pack in the event that jump starting is necessary

dc to 3-Phase ac Power Inverters:

- Insulated Gate BiPolar Transistors (IGBT) - the component that transfers the power to control the electric motor speed and torque
- How the Microcontroller generates control signals
- Learn how the Power Inverter creates ac from dc
- Discover why ac electrical power has superior efficiency and power density when compared to dc powered systems
- Voltage required to power the Induction and Permanent Magnet Machines
- Discover how Speed, Torque, and Regenerative Braking are generated and controlled
- Learn how the power inverter controls regenerative braking (generating electrical) power of the drive motor and what other functions control the regenerative process
- How Switching/Firing Order Patterns of the Stator are similar to that of an engine
- Learn how the Power Inverter controls Battery Pack recharging during vehicle coasting (regenerative braking)
- Compare Internal Combustion Engine and Induction Motor Scan Tool Information
- Discover the differences between active and passive high voltage bus discharge systems, why it is important to know how each system operates, and how the power inverter controls these systems
- Learn about how 3-phase electric machines have replaced belt-driven air conditioning compressors in some vehicles…..with more on the way

Battery Pack Systems:

- Learn the basics of the Battery Pack and why hybrid systems need 300 to 400 Volt Battery Packs
- Study the battery pack internal components and their function(s)
- An overview of battery ratings and how vehicle performance and range are affected
- Discover how the Battery Pack is constructed – batteries, controllers, contactor
- Learn the role of the Battery Pack Controller in controlling Battery Pack performance
- Learn about the service/manual disconnect system and why it is important to know where it is located and how to properly use it in emergencies and repair
- Study how the battery pack is mechanized to understand its operation
- Study the various battery pack thermal (cooling) systems and why a forced air system may not be enough to cool the battery pack system
- Learn about the many sensors within the battery pack and how these sensors provide information to other controllers for the purpose of controlling system electrical power
- Discover why HEV battery packs are not operated at 100% capacity…..and can typically operate between 50% and 80% state of charge

Analysis and Diagnostics

- Begin to understand how the Hybrid Electric Vehicle system will need to be analyzed, and how it differs from engine systems
- Discover what methods you will need to develop for analyzing and diagnosing a Hybrid Electric system
- Discover what new tools are necessary to analyze the electric machine (motor), power inverter, and battery pack systems
- Learn the new Scan Tool parameters and their meaning, how some of these parameters are similar to the engine system, and learn about all of the new parameters

Safety Systems

- Learn about the auto disconnect and manual disconnect systems and how you will use each one to ensure your safety when you repair the High Voltage systems on a Hybrid vehicle
- Discover what can happen if you don't disable the High Voltage system
- Learn about interlock systems and the differences of each system
- Study the bus discharge system and why not all manufacturers have utilized the same system designs……and what this means to your safety
- How to properly identify a high voltage circuit and how manufacturers have typically packaged these circuits

System Repair Issues

- Learn how these systems must be treated to repair and replace components
- Discover the locations of the battery pack, dc-dc converter, power inverter, and electric machines – and how these locations will affect the system repair
- Use your new found knowledge and apply it to a new world of possible driveability concerns