Training - Low-carbon fuels and processes

BIOCPP-EN-P | Face-to-face only | 3 days

This session provides general technical information on the characteristics and processes leading to key bio-based products and intermediates: existing and developing biofuels, petrochemicals and chemicals

Level

Expert

Public

Professionals from different technical departments in sectors ranging from refining to petrochemicals or involved in the energy transition

Objectives

Attendees will be able to implement the following skills:
Upon completion of the training, participants will be able to:

- • List the main characteristics of bio-based products on the current market
- • describe the principle of existing and developing processes

Pedagogical & technical resources

- • Interactive course: active participation of the trainees through games and quizzes to grasp the key points of the course.
- • Joint construction of a diagram of all bio-processes.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

Meet at least one of the following criteria:
• Have 3 months of proven professional experience in the energy sector, in a technical position.
• Or have followed a training course oriented towards the introduction to refining or petrochemical processes.

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

CONTEXT AND FEEDSTOCKS — 0.5 day

Challenges of carbon-free energy and bioplastics in the context of climate change.
Associated environmental and regulatory framework.
Process development strategy.
Different types of biomass: sugar biomass, starchy biomass, oilseed biomass, waste.

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Biomass generations: 1G, 2G, 3G
Other feedstocks:

- CO2, low-carbon hydrogen.
- Recycled plastics.

BIOFUELS AND PETROCHEMICAL INTERMEDIATES 0.5 day

Description of hydrocarbon molecules families: Olefins, Aromatics, Paraffins.
Main characteristics and specificities of the different biofuels and comparison between them:

- For gasoline engine (ETBE, ethanol).
- For diesel Engine (FAME, HVO).
- For Jet (HEFA, FT-SPK, ATJ, DSHC).
- For the maritime sector (Methanol, NH3, GNL).

Other energetic fuels (H2 /e-fuels).
Main intermediates for access to plastics or chemicals: Olefins, Aromatics, Methanol, Syngas.
Main polymers: Bio-based vs. biodegradable, bioplastics, recycled plastics.

LOW CARBON PROCESSES 2 days

Overview of processes for transforming feeds into intermediate and finished products: feedstocks and treatments, process diagrams, different technologies when relevant, typical operating conditions, advantages and drawbacks, comparison and maturity.
Current processes:

- ethanol by fermentation.
- ETBE by etherification.
- FAME by transesterification.
- HVO-HEFA by hydrotreatment.
- Co-processing.

Advanced processes:

- Biogas by digestion
- Biomethane by digestion or methanation.
- Different routes to syngas.
- Methanol and Ammonia via Syngas.
- Fuels by Fischer-Tropsch via syngas.
- Olefins by dehydration of alcools (ethanol and methanol).
- Different routes for SAF by ATJ, DSHC.
- Bio-crude /Py-oil by pyrolysis of biomass, wastes or plastics.
- Bio-oil by hydrothermal liquefaction.
- E-fuels production.

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Training - New Fuels: Impact on Engine and Turbine Operation

BIOMOT-EN-P | Face-to-face only | 3 days

This course provides a deeper knowledge on issues raised by the use of the new fuels planned for the near or further future: biofuels, gaseous fuels, synthetic fuels, alternative jet fuels

Level

Knowledge

Public

Engineers and technical staff involved in motor fuel quality management in relation to engine technologies

Objectives

Attendees will be able to implement the following skills:

- Analyze the context and development potential of alternative fuels (political context, potential of new sectors, standardization mechanisms for new products),
- Describe the main methods of obtaining these products and their economic and environmental impact, and know/recognize the main characteristics of these products,
- Evaluate the impact on the operation of piston combustion engines and turbines and define the resulting engine and vehicle adaptations.

Pedagogical & technical resources

Industry experts.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

No prerequisites are necessary to follow this course.

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

FUELS STRUCTURE & MAIN PROPERTIES — 0.5 day

Groups of hydrocarbons, alcohols, ethers, fatty acid esters.
Fuels required properties for engine operation

- Heat value, specific energy.
- Volatility: vapor pressure, distillation.

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- Combustion: octane rating and cetane rating.
- Cold flow properties: cloud point, CFPP, pour point.
- Lubricating properties.
- Viscosity.
- Sulfur content.
- Stability, corrosion.

Gasoline and Diesel fuel structures from oil bases. Specifications.

SYNTHETIC FUELS: GTL, BTL, CTL — 0.25 day

Processes to get such fuels.
Economic and environmental impacts.

BIOFUELS — 1 day

Situation and stakes

- Biofuels policies in the world: Brazil, United States and Europe situations.
- Biofuels production chains, well-to-wheel ecobalance, available resources.

Spark Ignited engine biofuels

- Production chains.
- Ethanol and ETBE characteristics.
- Potential and difficulties linked to the use of gasoline-alcohol mixtures: octane rating, latent heat of evaporation, water tolerance, volatility, corrosion, pollutant emissions, lubrication.
- Flex-fuel engines: difficulties linked to the use of ethanol high rated fuels, technical solutions.
- Second generation ethanol.

Biofuels for Diesel engines

- Use of direct vegetable oils (DVO) on Diesel engines: principles and limits. Fatty acid esters characteristics and impacts on the engine operating: solubility, “sulfur free”, lubricating properties, emissions, washing power, dilution, cetane rating, cold engine behavior, heating value.
- Storage stability, oxidation stability.
- "Biohydrocarbons” (hydrotreated oils): production modes, characteristics.

Biofuels for aeronautic turbine

- Certification, fit-for-purpose tests, drop-in fuel.
- Main certified (or in certification process) production ways: DVO hydrotreatment, synthetic biofuels, biological processes.
- Impact on logistics, aeroplanes and aeronautic turbines.

OTHER ALTERNATIVE FUELS — 0.25 day

Synthesis alternative fuels: GTL, BTL, Methanol (production processes).
Economical and environment impact.

GASEOUS FUELS: GPL-C, NGV (NATURAL GAS VEHICLE), DME, HYDROGEN — 0.25 day

Origins and resources of these fuels.

IMPACT OF NEW FUELS ON IC ENGINES & TURBINES OPERATION — 1 day

Impact of partial or full use of new fuels on performances, polluting emissions and on-board storage.
Case study and adaptation:

- Road transportation engines: passenger cars and trucks.

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- Industrial and stationary engines.
- Marine engines.
- Stationary turbines.
- Aero turbines.

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Training - Battery Validation and Calibration Tests

EBACARA-EN-P

Face-to-face only

5 days
Asynchronous part to be completed before the face-to-face part

This training course aims to improve skills in battery validation and calibration testing during the design phase

Level
Skilled

Public
Engineers and technicians who wish to design, develop, model, simulate, or use storage systems integrated into electric and hybrid electric vehicles, considering the technical, economic, and industrial constraints of the transportation industry

Objectives
Attendees will be able to implement the following skills:

- Understand and explain the main mechanisms of battery aging
- Understand and be able to explain the integration of aging constraints in battery design,
- Understand and explain battery malfunction and safety tests
- Know the main battery validation and calibration tests,
- Know how to analyze battery performance tests.

Pedagogical & technical resources
Teaching activities, tutorials, and practical work.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites
No prerequisites are necessary to follow this course.

Responsable
IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE COMPLETED BEFORE THE SYNCHRONOUS/IN-PERSON COURSE

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VIDEOS

Video 1 - Atoms Li-ions.
Video 2 - How batteries work.
Video 3 - Introduction to Lithium.
Video 4 - Composition of Li-ion batteries.
Video 5 - How Li-ion batteries work.

SYNCHRONOUS/IN-PERSON PROGRAM

BATTERY AGING MODELING AND CALIBRATION (LECTURES + PRACTICALS) 2 days

Aging of Li-ion cells.

- Aging mechanisms.
- Description of the main aging phenomena.

Modeling of Li-ion cell aging.

- Approaches.
- Aging models.
- Elements of thermodynamics, electrochemical kinetics, and mass transport.
- Model input parameters.

Tutorial work on battery design models.

- Applications: identifying limiting phenomena, cell design assistance, measurement of physical and geometric parameters.
- Other types of battery models: electrical analogy, simplified models, 3D cell model, resolved 3D microstructural models.

DYSFUNCTIONAL TESTS AND BATTERY SAFETY 1 day

Integration constraints.
Operational safety – safety concept.
Abuse tests.
Thermal propagation:

- Thermal propagation/runaway.
- Vibration.
- Thermal shock and cycling.
- Mechanical shocks.
- Mechanical integrity.
- Fire resistance.
- Protection against external short circuits.
- Overload protection.
- Overheating protection.
- Overcurrent protection.
- Low temperature protection.

Safety/abuse testing: in accordance with recognized standards (transport of hazardous materials – UN, ELLICERT, etc.):

- Mechanical (crushing, penetration, immersion, falling, etc.).
- Electrical (overload, over-discharge, short circuit, etc.).
- Thermal.

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PRACTICAL WORK: BASICS OF FUNCTIONAL CHARACTERIZATION TESTS FOR AN IN-VEHICLE APPLICATION — 1 day

Electrochemical characterization on educational test benches.
Familiarization with the main characterization and calibration tests required in the Integration Plan Vehicle (IPV), applied to demonstration electrochemical cells.

FUNCTIONAL PERFORMANCE TESTS (LECTURES/PRACTICALS) — 0.75 days

Drafting/monitoring of specifications and functional requirements for an automotive embedded application.
Analysis of electrical GMP specifications and drafting of battery specifications for supplier consultation: specifications. Performance - integration specifications - cost specifications, autonomy performance.
Identification of the main functional requirements of the specifications.
Breakdown of battery pack requirements into modules and cells.
Identification of the main functional characteristics required of the cells and the various characterizations and calibrations to be performed. Expected mission profiles.
Drafting of a simplified Vehicle Integration Plan.
Monitoring of IPV requirements. Analysis of various supplier feedback (4 to 6). Summary of results and justification of design choices based on performance, integration, and cost criteria.

EXAM — 0.25 day

Verification of acquired knowledge.

Sessions

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Training - Battery Manufacturing

EBAFAB-EN-P

Face-to-face only

5 days
Asynchronous part to be completed before the face-to-face part

This training course aims to improve skills in battery manufacturing

Level
Skilled

Public
Engineers and technicians who wish to design, develop, model, simulate or use storage systems integrated into electric and hybrid electric vehicles, taking into account the technical, economic and industrial constraints of the transport sector

Objectives
Attendees will be able to implement the following skills:

- Understand and explain the challenges of strategic battery materials,
- Understand and explain the main stages of battery manufacturing,
- Understand the digitization of battery manufacturing processes,
- Understand and explain the synthesis of active battery materials.

Pedagogical & technical resources
Teaching activities.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites
No prerequisites are necessary to follow this course.

Responsable
IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE COMPLETED BEFORE THE SYNCHRONOUS/IN-PERSON COURSE

VIDEOS

Video 1 - Atoms Li-ions.
Video 2 - How batteries work.

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Video 3 - Introduction to Lithium.
Video 4 - Composition of Li-ion batteries.
Video 5 - How Li-ion batteries work.

SYNCHRONIZED/IN-PERSON PROGRAM

RAW MATERIALS. STRATEGIC MATERIALS — 0.5 day

Strategic materials and geopolitics.
Materials for batteries: graphite (anode), aluminum (cell casing, cathode, collectors), nickel (cathode), copper (collectors), manganese (cathode), cobalt (cathode), lithium (cathode), iron (cathode), steel (cell casing).
New families of disruptive active materials.
Lithium insertion materials.
Synthesis of lithium insertion materials.

CELL MANUFACTURING AND MODULE ASSEMBLY — 1.5 days

Overall process and environmental conditions.
Process.
Components introduced.
Focus on ATEX risks.
Steps.
Characteristics.
Things to keep in mind.
Mixing; Coating; Calendering and slitting; Cutting; Cell assembly; Electrolyte filling; SEI formation/degassing; Electrolyte filling; Cell assembly within the module.

DIGITALISATION OF BATTERY MANUFACTURING PROCESSES — 1 day

Part one:

- Definitions.
- Models.
- State of the art in physical process models.
- Focus on each step of the battery manufacturing process: mixing electrode inks, coating, drying, calendering.
- Generative methods for microstructured electrodes.
- Educational models for electrode manufacturing.

Part two:

- Electrolyte infiltration.
- Electrochemical performance.
- Cell optimization.
- Human/machine interfaces.

CHEMISTRY OF LI-ION CELL CORE MATERIALS AND DEVELOPMENTS — 1 day

Atomistics and electrochemistry: fundamentals and applications to the physical and chemical properties of materials used in Li-ion cell cores.
Synthesis of active materials: different approaches, key players, challenges, and avenues for improvement.
Comparison of the electrochemical and physicochemical properties of different active materials.
Tutorial: comparisons of mass/material balances for Li-ion batteries with different chemistries.

CORYS MANUFACTURING MODELING OF LI-ION CELLS (WORKSHOP) — 0.75 day

General principles of battery manufacturing processes.
Presentation and introduction to the simulator.
Presentation of the positions considered.

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Simulator-based scenario exercises.

EXAM **0.25 day**

Verification of acquired skills.

Sessions

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Training - Modeling as an Aid to Battery Design

EBATMOD-EN-P

Face-to-face only

5 days
Asynchronous part to be completed before the face-to-face part

This training aims to improve learners' skills in modeling as a tool for designing cells and battery packs in the design phase

Level
Skilled

Public
Engineers and technicians who wish to design, develop, model, simulate or use storage systems integrated into electric and hybrid electric vehicles, considering the technical, economic and industrial constraints of the transport sector

Objectives
Attendees will be able to implement the following skills:

- Understand fundamental electrochemical laws,
- Understand Newman-type modeling methodologies,
- Understand and explain the design of a Li-ion cell based on a Newman-type model,
- Understand and explain the use of modeling in battery pack design,
- Be able to use the AMESIM tool.

Pedagogical & technical resources
Teaching activities and tutorials.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites
No prerequisites are necessary to follow this course.

Responsable
IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE COMPLETED BEFORE THE SYNCHRONOUS/ FACE-TO-FACE COURSE

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VIDEOS

Video 1 - Atoms Li-ions.
Video 2 - How batteries work.
Video 3 - Introduction to Lithium.
Video 4 - Composition of Li-ion batteries.
Video 5 - How Li-ion batteries work.

SYNCHRONOUS/FACE-TO-FACE PROGRAM

ELECTROCHEMICAL MODELING AS AN AID TO LI-ION CELL DESIGN (LECTURES/PRACTICALS) — 3 days

Introduction:

- Main half-reactions, equilibrium potentials, and electrolyte stability window.
- Solid-state insertion and phase transition mechanisms.
- Volumetric electrodes and their characteristic parameters.
- Internal cell balancing and the unique characteristics of each technology.
- Introduction to the kinetic thermodynamics of batteries.
- Kinetic stages: double electric layer, ohmic drop, and crystallization overvoltage.
- Kinetic stage: charge transfer overvoltage.
- Kinetic stages: diffusion overvoltage.
- Battery cell in operation.
- Factors affecting battery performance.
- Battery design and voltage.

Electrochemical techniques:

- Galvanostatic cycling and measurement of capacity, coulombic efficiency, and energy efficiency.
- Constant current/constant voltage (CCCV) charging.
- Influence of current on galvanostatic charging and discharging.
- Measurement of pulse resistance and maximum power.
- Ragone diagrams.
- Peukert diagrams.
- Impedance spectroscopy.
- Measurements on half cells.
- Intermittent galvanostatic and potentiostatic measurements, incremental capacity curves.
- Battery durability and aging.
- Main aging phenomena.
- Effects of aging phenomena on cell performance (loss of capacity, power, reversible and irreversible self-discharge).
- Cell aging tests.
- Analysis of aging data using performance models (behavioral, electrochemical, etc.). Contribution of postmortem analyses.
- Aging models (empirical, physical, etc.).

Electrochemical modeling:

- Elements of thermodynamics, electrochemical kinetics, and mass transport.

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- Presentation of the electrode/separator/electrode+ (Li-ion) stack model.
- Model input parameters.
- Applications: identifying limiting phenomena, cell design assistance, measurement of physical and geometric parameters.
- Other types of battery models: electrical analogy, simplified models, 3D cell model, resolved 3D microstructural models.

Tutorials:

- Tutorial analysis of a Li-ion cell design (jelly roll thickness, percolating carbon grain size, porosity of active materials, etc.) based on a Newman model.

Electrochemical modeling:

- Elements of thermodynamics, electrochemical kinetics, and mass transport.
- Presentation of the electrode/separator/electrode+ (Li-ion) stack model.
- Model input parameters.
- Applications: identifying limiting phenomena, cell design assistance, measurement of physical and geometric parameters.
- Other types of battery models: electrical analogy, simplified models, 3D cell model, resolved 3D microstructural models.

AMESIM MODELING AS AN AID TO PACK SYSTEM DESIGN (LECTURES + WORKSHOPS) — 1,75 days

Presentation of Amesim - Tutorials on examples of battery applications for electric traction:

- Introduction to Simcenter Amesim and battery modeling - Practical.
- Identification of battery requirements - Practical.
- Creation of a cell and pack model that meets these requirements.
- Creation of a battery thermal management model.
- Impact of battery module design during thermal runaway.
- Calibration of the aging model and exploitation.

REVIEW — 0.25 day

Verification of acquired knowledge.

Sessions

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Training - Fundamentals of Electrical Engineering applied to Power Electronics

ELECTRO-EN-P

Face-to-face only

5 days
The first part must be completed before the classroom training

This training aims to provide learners with the basics of electronics necessary to tackle power electronics. It covers passive and active components, as well as basic circuits, to establish the fundamental knowledge needed to understand and design power electronics systems

Level
Knowledge

Public
Engineers and technicians with industrial experience, regardless of sector, who wish to specialize in power electronics or deepen their knowledge of applied electronics, particularly for applications in electric and hybrid vehicles (R&D engineers - Test and validation technicians - Systems engineers and architects - Engineers and technicians retraining in the electrical field - Test, design office, or CAD technicians)

Objectives
Attendees will be able to implement the following skills:

- Understand and use passive components (capacitors, resistors, inductors, transformers) and active components (diodes, transistors, integrated circuits) in signal conditioning or processing circuits in power electronics systems.
- Analyze the transient and sinusoidal responses of basic circuits (RC, RL, RLC) and apply Fourier and Laplace transforms in the study of these circuits.
- Analyze the frequency characteristics of real components.
- Implement signal processing circuits, including operational amplifiers and comparators, for signal conditioning and protection.
- Design driver stages for power transistor control and understand the control logic of power circuits,
- Use microcontrollers to control power electronic circuits, including PWM signal generation for power converters.
- Test and characterize the performance of basic electronic circuits, including RLC circuits and drivers.

Pedagogical & technical resources

- Integrated training combining theory and practice on a continuous basis.
- Theoretical courses supplemented by practical work and experiments in the classroom, including circuit assembly and real measurements.
- Simulations and calculations using specialized software to reinforce understanding of electronic circuits.
- Use of measuring instruments (oscilloscopes, multimeters, current probes, differential voltage probes, signal generators) to illustrate the principles of circuit measurement and analysis.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each

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module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

No prerequisites are necessary to follow this course.

Complementary informations

All courses in this module will be applied in practical work, tutorials, or case studies. The courses include exercises in simple electronic circuit design, simulation analysis, calculations, and real-time measurements

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE FOLLOWED BEFORE THE FACE-TO-FACE COURSE

VIDEOS

Capacitors and resistors.
Inductors and transformers.
Diodes and transistors.
Operational amplifiers and comparators.
Microcontrollers and PWM generation.
Fundamental electrical circuits: RC, RL, and RLC.

SYNCHRONOUS/FACE-TO-FACE PROGRAM

TRANSITIONAL CIRCUITS: INDUCTANCE AND RL CIRCUITS — 0.25 day

This course explores the transient responses of RL circuits, analyzing the behavior of inductors when subjected to voltage changes. Participants will learn how to model and analyze these circuits under switching conditions. Time and frequency analysis of the response. Notions of transfer functions. This course is fundamental for understanding the precise operation of inductors, filters, and static energy converters.

TRANSITIONAL CIRCUITS: CAPACITORS AND RC CIRCUITS — 0.25 day

This module focuses on the transient responses of RC circuits. Participants will learn how capacitors respond to voltage changes and how this affects the charging and discharging dynamics in circuits. Time and frequency analysis of the response. Introduction to transfer functions. This course is fundamental for understanding the precise operation of capacitors, filters, snubbers, time circuits, and parasitic components in static power converters.

TRANSITIONAL CIRCUITS: RLC CIRCUITS — 0.25 day

RLC circuits combine resistors, inductors, and capacitors, resulting in complex transient behavior. This course teaches how to analyze the natural and forced responses of these circuits, with practical examples of damped oscillations. This course is fundamental for understanding real models of electronic components and the operation of soft-switching converters.
Study of RC, RL, and RLC circuits: Fourier transforms, and Laplace transforms through practice: Application of Fourier and Laplace transforms to the study and design of electronic circuits (filters and power stages). Use of transforms in the study of RC, RL, and RLC circuits.

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TRANSITIONAL CIRCUITS: TESTING AND CHARACTERIZATION OF RLC CIRCUITS — 0.25 day

This practical course focuses on methods for testing and characterizing RLC circuits. Participants will learn how to measure characteristic parameters and interpret transient responses using test tools.

SINUSOIDAL CIRCUITS: RL CIRCUITS — 0.25 day

In this module, participants will study the sinusoidal behavior of RL circuits, focusing on the concepts of impedance and phase shift between current and voltage. This course is fundamental for understanding the operation of AC machines and inverter control. Concept of complex impedance and vector representation.

SINUSOIDAL CIRCUITS: RC CIRCUITS — 0.25 day

This course examines the behavior of RC circuits under sinusoidal conditions, with a focus on filtering applications and frequency response calculation. Concepts of complex impedance and vector representation.

SINUSOIDAL CIRCUITS: RLC CIRCUITS — 0.25 day

This module explores RLC circuits in sinusoidal mode, covering the concepts of resonance, bandwidth, and circuit quality. Participants will learn how to calculate and analyze these parameters. This course is fundamental for understanding real-world models of electronic components and the operation of soft-switching converters. Introduction to complex impedances.

SINUSOIDAL CIRCUITS: THREE-PHASE CIRCUITS — 0.25 day

Three-phase circuits are at the heart of power systems. This course covers the basics of three-phase systems, star and delta connections, and the calculation of active and reactive power in these systems.

FUNDAMENTALS OF ACTIVE COMPONENTS: TRANSISTORS AND DIODES — 0.25 day

This course presents the basic principles of junction and field-effect transistors, diodes, their characteristics, and their applications in power electronics. Participants will study the linear conduction and switching properties as well as the limitations of these components. This course covers the fundamental knowledge required to study all electronic circuits.

SIGNAL ELECTRONICS: IMPLEMENTATION FOR POWER ELECTRONICS — 0.25 day

This module explores signal processing circuits used in power electronics, including signal conditioning, amplification, and component protection.

SIGNAL ELECTRONICS: DRIVER STAGE DESIGN — 0.25 day

This course focuses on the design of driver stages for power transistors, addressing control requirements and necessary protection circuits.

ANALOG ELECTRONICS: OPERATIONAL AMPLIFIERS – PRINCIPLES — 0.25 day

Operational amplifiers are essential components in analog electronics. This module covers their operating principles, basic configurations, and common applications. Their application in signal processing: comparators, subtractors, integrators useful in power electronics in the implementation of analog regulators.

ANALOG ELECTRONICS: CONTROLLER DESIGN — 0.25 day

This course teaches the design of analog voltage regulators, with a focus on linear regulators and stability and efficiency characteristics.

ANALOG ELECTRONICS: COMPARATORS AND OSCILLATORS — 0.25 day

This course introduces comparators and oscillators, their operating principles, and their applications in measurement, protection, control, and signal generation circuits.

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COMBINATIONAL ELECTRONICS: LOGIC CIRCUITS AND FLIP-FLOPS 0.25 day

Participants will learn the basics of combinational logic, including basic logic circuits and flip-flops used in digital signal processing.

COMBINATIONAL ELECTRONICS: APPLICATION - BRIDGE DRIVER LOGIC 0.25 day

This course focuses on the control logic of bridge drivers for power transistors, enabling the management of power converter control signals.

DIGITAL ELECTRONICS: HOW A MICROCONTROLLER WORKS 0.25 day

This course introduces the operation of microcontrollers, their internal structure, and their programming for power electronics applications.

DIGITAL ELECTRONICS: APPLICATION - PWM GENERATION 0.25 day

This course covers the generation of PWM (pulse width modulation) signals for power converter control, focusing on frequency, resolution, and modulation aspects.

EXAM & ASSIGNMENTS 0.25 days

This final session is dedicated to assessing the knowledge acquired during the week and completing tutorials to apply the concepts studied.

Sessions

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Training - Electric Drives for Automotive Propulsion Design, Modeling & Simulation

EMOT-EN-P

Face-to-face only

5 days

This course provides a deeper knowledge on how to design, build a model and simulate electrical drives, integrate the automotive needs and constraints

Level

Knowledge

Public

Design or test engineers or technicians, currently working at manufacturers or OEM in automotive trucks or off-road fields and wishing to design, develop, model, simulate, specify or use electrical drives in electric and hybrid projects involving technical and economic constraints

Objectives

Attendees will be able to implement the following skills:

- Explain the operation, design, dimension, model, and simulate electric drives and power electronics (control principles),
- make architectural choices based on dimensioning calculations.

Pedagogical & technical resources

- Design, modeling, and simulation of electric drives using simulation software.
- Sizing of cooling circuits for electric drives and power electronics using Matlab-Simulink.
- Case studies of system architecture choices, integrating the technical, industrial, and economic constraints of the automotive industry.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

No prerequisites are necessary to follow this course

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

AUTOMOTIVE ELECTRICAL DRIVES — 1.75 days

Fundamental of electrotechnics: electrical measurements, electrical components: magnets, conductors, magnetic materials, magnetic circuits, production of magnetic fields, magnetic forces, electromagnetic

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induction, impedances (inductors, capacitors, electrical circuits), vector calculations (voltages and sinusoidal voltages, vector diagram, power calculation, currents, active and reactive power), electrical machines losses, performances and dimensions, single and three phase, real and ideal transformers.
DC machines: fundamentals, equivalent electrical circuit, design rules, design and layout constraints, manufacturing processes, industrial and economic aspects, examples of vehicle applications.
Synchronous machines: fundamentals, equivalent electrical circuit, design rules, design and layout constraints, manufacturing processes, industrial and economic aspects, examples of application of vehicle.
Induction machines: fundamentals, equivalent electrical circuit, design rules; design and layout constraints; manufacturing processes, industrial and economic aspects; examples of application of vehicle.
Cooling: cooling technologies, design rules, electrical machines heat losses calculation.

AUTOMOTIVE ELECTRICAL DRIVES POWER ELECTRONICS — 0.75 day

Power electronics for machines control: choppers, inverters, rectifiers; technology, design and operation; characteristics, layout constraints, thermal and vibration aspects; electromagnetic compatibility; manufacturing processes, industrial and economic aspects; examples of vehicle applications.
Power components: fundamentals, design and operations; conduction and switching losses; cooling (technologies, operation and design).

AUTOMOTIVE ELECTRICAL MACHINES CONTROL — 0.5 day

Reminders on electrical machines control with electric or hybrid vehicles. Reminders on energy management with electric or hybrid vehicles. Torque and speed control issues.
PWM construction and theory. DC machines torque control.
Vector control. Park Equations. Flux and torque control of synchronous and induction machines.
Sliding mode control of induction motors.

POWER ELECTRONICS DESIGN, MODELING & SIMULATION — 1 day

Chopper design, modeling and simulation with PSpice.
Bridge and three-phase inverter design, modeling and simulation with PSpice. Power electronics losses modeling.

ELECTRIC MACHINES MODELING & SIMULATION — 1 day

Electric machines modeling and simulation with equivalent circuits.
DC machine modeling and simulation. Real machine datasheet analyzes. Model design and calibration with Matlab-Simulink. DC machine and chopper torque control modeling and simulation.
Induction machine modeling and simulation. Real machine datasheet analyzes. Model design and calibration with Matlab-Simulink.
Induction machine and three-phase inverter chopper torque control by sliding speed modeling and simulation.
Synchronous machine modeling and simulation. Real machine datasheet analyzes. Model design and calibration with Matlab-Simulink.
Synchronous machine and three phase inverter torque control by oriented vector control (implementation of equations Park) modeling and simulation.

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Training - Fundamentals of Electrical Engineering

ETECHE-EN-P

Face-to-face only

5 days

The first part must be completed before the classroom training

This training aims to provide learners with essential knowledge in electrical engineering, covering the fundamental principles of electric and magnetic fields, the laws of electricity, and the basics of electromechanical conversion. It establishes a solid foundation for understanding electrical circuits and active components, which are necessary in power electronics applications

Level

Knowledge

Public

Engineers and technicians (with industrial experience in any sector) who wish to deepen their knowledge of electrical engineering in order to apply it in the field of power electronics, particularly in electric and hybrid vehicles (R&D engineers - Test and validation technicians - Systems engineers and architects - Engineers and technicians wishing to work in the electrical field, currently retraining - Test, design office or CAD technicians). A good grounding in mathematics (vector calculus, differential equations, Fourier transforms) is required

Objectives

Attendees will be able to implement the following skills:

- Understand the basic concepts of electrostatics, electrical energy, and related quantities (current, voltage, power)
- Measure and interpret current, voltage, and power values accurately using various sensors and measuring instruments,
- Analyze and calculate the characteristics of electrical circuits, including Kirchhoff's laws and Thévenin's and Norton's theorems.
- Apply the principles of magnetic fields and induction to understand the operation of transformers and electrical machines,
- Design and specify inductors and transformers,
- Test and evaluate the performance of inductors and transformers under various conditions.

Pedagogical & technical resources

- Integrated training combining theory and practice throughout.
- Theoretical courses supplemented by practical work and experiments in the classroom, including real-life setups and measurements.
- Simulations and calculations using specialized software to reinforce understanding.
- Use of sensors, oscilloscopes, current clamps, multimeters, differential voltage probes, and other instruments to illustrate the principles of circuit measurement and analysis.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

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Prerequisites

No prerequisites are necessary to follow this course.

Complementary informations

Applications for this entire module: design of simple assemblies or circuits to illustrate and apply all these fundamental concepts. Analysis of assemblies and circuits based on calculations, simulations, and measurements. Practical work in the classroom. The courses include exercises in simple circuit design, electronic component design, and analysis through simulation, calculation, and measurement

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE FOLLOWED BEFORE THE FACE-TO-FACE COURSE

VIDEOS

Concepts of electric fields and electric potential.
Concepts of electricity and electrical energy.
Concepts of impedance and resistance.
Concepts of inductance, capacitance, and transformers.
Electrical power.
Kirschhoff's laws.

SYNCHRONOUS/FACE-TO-FACE PROGRAM

FUNDAMENTALS OF ELECTRICITY — 0.25 day

This course presents the basics of electrical engineering by covering the fundamental concepts of electrostatics, electrical energy, and related physical quantities such as electric currents, voltages, and power. Participants will discover the principles of electric fields and electrostatic forces and study the relationship between energy and charges in an electrical system. Fundamental physics of conductors, insulators, and capacitors.

MEASUREMENTS, SENSORS, AND TESTS - CURRENT MEASUREMENT AND RELATED TECHNOLOGIES — 0.25 day

This course focuses on current measurement techniques in electrical engineering systems. Participants will be introduced to different types of current sensors and measuring instruments, such as shunts, current clamps, and current probes, as well as their operating principles. Related technologies and their applications in the context of electrical engineering will also be covered, with an emphasis on the accuracy, sensitivity, and calibration of devices and sensors.

MEASUREMENT, SENSORS, AND TESTING - VOLTAGE MEASUREMENT AND RELATED TECHNOLOGIES — 0.25 day

This course covers voltage measurement methods, and the technologies used for this measurement. Students will explore different sensors and equipment for voltage measurement, including voltmeters, voltage probes, and oscilloscopes. They will also learn techniques for selecting the appropriate instrument and sensor based on applications and insulation and safety constraints. Particular attention will be paid to the accuracy and limitations of voltage measurement equipment under real-world conditions.

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MEASUREMENTS AND TESTS - WAVEFORM MEASUREMENT, OTHER MEASUREMENTS AND TECHNOLOGIES — 0.5 day

This course covers the measurement and analysis of electrical waveforms in electrical engineering circuits and systems. Participants will become familiar with instruments such as oscilloscopes and spectrum analyzers and will learn how to interpret waveforms based on signal characteristics (frequency, amplitude, phase, etc.). They will discover how these technologies can be used to identify and analyze signal characteristics, including anomalies and distortions. The course also covers signal analysis techniques in the time and frequency domains. Measurement of currents, voltages, and power: use of oscilloscopes, current clamps, differential voltage probes, and calculation of power and energy using oscilloscopes. Measurement of temperature, position, and speed. Sensors, estimators, and observers. Sensor technologies used in power electronics. Application to measuring instruments: impedance meters, thermometers. General knowledge of metrology.

CURRENTS, POTENTIALS, CONDUCTORS AND INSULATORS — 0.25 day

This course reinforces the concepts of electrical currents and potentials, as well as the properties of conductors, semiconductors, and insulators. This course will provide the foundation for understanding the behavior of materials under the influence of electric fields and the differences between conductors, semiconductors, and insulators. Nature of electricity, electrical measurements and quantities, concepts of current, voltage, potential, electrical circuit topology (meshes, branches, nodes), Ohm's law, electrical power and energy, insulators, conductors and resistances, electrostatic phenomena, capacitance.

BASICS OF ELECTRICAL CIRCUITS — 0.25 day

This course introduces the fundamental principles of electrical circuits. Participants will explore Kirchhoff's laws, sign conventions for currents and voltages, and basic calculations of current, voltage, and power in simple circuits.
This module is essential for understanding the operation and analysis of direct current and alternating current circuits, with practical applications in circuit problem solving. Kirchhoff's laws in AC and DC, vector diagrams, active, reactive, and apparent power, Thévenin's and Norton's theorems, basic concepts of impedance (covered in more detail in the next module on the fundamentals of electronics), calculation of currents, voltages, and powers in electrical circuits.
Analysis of the characteristics of a real electrical circuit. Calculation of thermal losses, useful power, and efficiency.

MAGNETIC FIELDS, FLUX AND INDUCTION — 0.25 day

This course explores the concepts of magnetic fields, flux, and induction, which are fundamental to electrical engineering and power electronics applications. Participants will learn how to calculate magnetic flux and understand the phenomenon of electromagnetic induction. This course will provide an understanding of the practical applications of induction, such as transformers and electric machines, and introduces Faraday's law and Lenz's law.

MAGNETIC ENERGY — 0.25 day

This course explores the concept of magnetic energy, which is an essential component of electromagnetic systems. Participants will study how energy is stored in magnetic fields and its role in devices such as inductors and transformers. This module also covers the principles of energy conservation in magnetic systems and presents practical applications in the fields of electrical engineering and power electronics.

MAGNETIC MATERIALS & PERMEABILITY — 0.25 day

This course focuses on the properties of magnetic materials, particularly permeability, which determines a material's ability to channel magnetic fields. Students will learn about different types of magnetic materials, their characteristics, and their use in electrical components such as transformers and motors. This module also introduces the concept of magnetic saturation and its impact on the performance of magnetic devices.

MAGNETIC CIRCUITS — 0.25 day

This course introduces magnetic circuits, drawing analogies with electrical circuits to facilitate understanding.

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Participants will study the laws governing magnetic circuits, such as Ohm's law and Kirchhoff's law applied to magnetic flux. This course is crucial for understanding the operation and sizing of inductors, transformers, and other equipment requiring effective management of magnetic circuits.

MAGNETIC FORCES 0.25 day

In this course, learners will discover the forces generated by magnetic fields, including the Lorentz force, the force exerted on ferromagnetic materials, and the principles of electromagnetic torque. This module covers the basic principles for calculating and understanding these forces and their application in electric motors, electromagnets, and magnetic lifting devices such as relays. Particular attention will be paid to practical applications and the impact of magnetic forces on electromechanical systems.

INDUCED VOLTAGE AND ELECTROMAGNETIC POWER 0.25 day

This course explores the phenomenon of voltage induced in a conductor moving in a magnetic field, which is the basis for electricity generation in electromechanical systems. Participants will study Faraday's law and the basic principles of electromagnetic power. This module includes practical applications, such as understanding generators and motors, where induced voltage and electromagnetic power play a crucial role.

INDUCTANCE DESIGN 0.25 day

This course focuses on the design of inductors, key components in filtering and power conversion circuits. Participants will learn the basic principles for sizing an inductor, material choices, and considerations related to losses and operating frequency. This course also provides an introduction to different inductor topologies and selection criteria based on applications.

INDUCTANCE TESTING 0.25 day

This hands-on course is dedicated to inductance testing methods for evaluating performance in a circuit. Participants will learn how to measure the essential characteristics of an inductance, such as resistance, impedance, and quality factor. They will also discover testing techniques for evaluating inductance losses and durability under various load conditions.

SIMPLIFIED OPERATION OF ELECTRICAL MACHINES 0.25 day

This course covers the operation, basics, and (simplified) modeling of electric machines. Participants will apply magnetic principles and the principles of energy conversion between electrical and mechanical energy to understand how they work. They will also cover the main characteristics of different types of machines (synchronous, asynchronous, direct current, etc.). This course provides power electronics engineers with the general knowledge of electrical machines necessary to tackle the design of choppers and inverters. Equivalent electrical circuit of electrical machines (Thevenin model of electrical machines); design parameters; simple modeling and simulation of an electrical machine and its control via the equivalent electrical circuit. Principles of electromagnetic torque and torque characteristics of electrical machines, technologies, principles.

PHYSICS OF ELECTRICAL ENGINEERING: TRANSFORMER DESIGN 0.25 day

This course covers the fundamental principles of transformer design, examining material choices, sizing criteria, and parameters influencing efficiency and performance. Participants will learn how to design transformers suitable for different applications, considering operating frequency, Joule losses, and magnetic losses. This module also includes practical considerations for optimizing compactness and heat dissipation in transformers.

TRANSFORMER TESTING 0.25 day

This course focuses on transformer testing methods to evaluate performance and compliance with specifications.
Participants will learn how to measure key parameters such as resistance, magnetizing inductance, leakage inductances, efficiency, and losses. They will also discover short-circuit and load testing techniques to evaluate the reliability and durability of transformers under various operating conditions. They will observe the effects of magnetic saturation.

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Sessions

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Training - Fundamentals of Power Electronics

ETRON-EN-P

Face-to-face only

5 days
The first part must be completed before the classroom training

This training course aims to introduce learners to the fundamental principles of power electronics, covering components, switching cells, and basic structures. It provides the basis for understanding energy conversion processes and DC-DC topologies, which are essential for designing power circuits in industrial and transportation applications

Level
Knowledge

Public
This training course is intended for Engineers and technicians with industrial experience, regardless of sector, who wish to acquire or consolidate their skills in power electronics, particularly in the fields of electric and hybrid vehicles (R&D engineers - Test and validation technicians - Systems engineers and architects - Engineers and technicians retraining in the electrical field - Test, design office, or CAD technicians)

Objectives
Attendees will be able to implement the following skills:

- Understand the principles of switching in electronic circuits and the role of the switching cell,
- Apply switching mechanisms for transistors and diodes and optimize the performance of power devices by reducing losses,
- Analyze and compare dc-dc conversion topologies (buck, boost, buck-boost) and understand their advantages and disadvantages in terms of efficiency and compactness,
- Identify and specify the appropriate technologies for inductors, transformers, and capacitors, based on frequency and performance characteristics,
- Implement reliability and protection solutions for electronic systems, including surge, overcurrent, and short-circuit protection architectures.
- Apply appropriate cooling techniques for power components to ensure thermal stability in demanding environments.

Pedagogical & technical resources

- Integrated training combining theory and practice on an ongoing basis.
- Theoretical courses supplemented by practical work and experiments in the classroom, including circuit assembly and real measurements.
- Use of specialized software for simulating and calculating the thermal and electrical performance of components.
- Advanced measuring instruments (oscilloscopes, multimeters, current probes, spectrum analyzers) to illustrate the principles of switching and measurement in power circuits.
- Analysis of industrial parts, printed circuit boards, and electronic components at the cutting edge of power electronics technology.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the

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trainer

- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

No prerequisites are necessary to follow this course.

Complementary informations

All courses in this module will be applied in practical exercises, tutorials, or case studies. The courses include exercises in DC-DC conversion circuit design, thermal management, and simulation analysis for a thorough understanding of the topics. For participants with no knowledge of signal electronics applied to power electronics: see ELECTRO-FR. For participants with no experience in electricity: see ETECHE-EN and ELECTRO-EN

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE FOLLOWED BEFORE THE FACE-TO-FACE COURSE

VIDEOS

Capacitors in filters.
Inductors in filters.
Diodes and transistors in switching.
Fundamental structures of power electronics: choppers and elevators.
Transistor and diode switching.

SYNCHRONOUS/FACE-TO-FACE PROGRAM

PRINCIPLE OF DISCONNECTION: SWITCHING CELL — 0.25 day

This course introduces the principles of switching in electronic circuits, particularly the switching cell. Participants will learn the fundamentals of energy conversion by switching and the characteristics of switching cells including transistors, diodes, and inductors used in power converters. Fundamental principles of power electronics and the use of power electronics. Basic semiconductor devices. Implementation of power electronic devices. Power electronics components: semiconductors and passive components (L, C). Principle of switching. The switching cell, determination of static characteristics. Concept of natural switching, influence of supply voltage and load current on the nature of switching.

SWITCHING MECHANISMS: SUITABLE TECHNOLOGIES — 0.25 day

This course explores switching mechanisms and the technologies used around the cell to optimize this process: diodes, IGBTs, MOSFETs, semiconductor technologies, drivers, output filters, and input filters. Participants will learn techniques for reducing switching losses and improving the efficiency of power devices.
Component switching: dynamic characteristics, switching and control of MOSFETs, IGBTs and power diodes: dynamic behavior in a switching cell. Influence of parasitic capacitances and inductances in the actual circuit. Switching aid circuits. Limitations, constraints and switching performance: calculation of conduction and switching losses.

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BASIC DIAGRAMS FOR DC-DC CONVERSION 0.25 day

This course presents the basic diagrams used for DC-DC converters, including Buck, Boost, and Buck-Boost topologies. Participants will examine the operating principles, applications, disadvantages, and advantages of each topology.
Principles of DC-DC conversion. Series (Buck), parallel (Boost), inductive storage (Buck-Boost), capacitive storage (Cuk, Sepic, and Zeta) choppers: principles, operation, constraints, sizing and sizing factors, voltage and current ripple, continuous and discontinuous modes. Comparison of topologies: advantages and disadvantages.
Control: choice of duty cycle, different types of control: fixed frequency, variable frequency, current range control and self-oscillating control.

COMPARISON OF DIAGRAMS: OPERATING MODES 0.25 day

In this course, the different DC-DC conversion topologies are compared according to their continuous and discontinuous conduction modes. Participants will study the criteria for selecting circuits based on efficiency, compactness, and cost constraints.

INDUCTANCE TECHNOLOGY 0.25 day

This module covers the technologies and characteristics of inductors, which are essential components in power conversion circuits. Participants will learn about the different types of inductors, the materials used, windings, material selection, the influence of frequency, and detailed sizing methods. Ideal and actual characteristics, frequency limitation.
Inductors: principles, operation, technology, constraints, performance, limitations, modeling, and sizing.
Compactness of magnetic components: increasing switching frequency, minimizing losses to reduce the surface area required for heat dissipation, optimizing converter topology. The merit factor of materials.
Magnetic materials for power electronics and their optimal frequency range. Eddy current losses. Different types of magnetic circuits.
Amorphous materials, nanocrystalline materials, nature of ferrites; advantages of low-permeability materials in the manufacture of inductors. Litz wire. Multilayer PCB technology. Influence of the choice of converter on transformer dimensions.

TRANSFORMER TECHNOLOGY 0.25 day

This course explores transformer design and manufacturing technologies. Participants will learn material selection criteria and techniques for optimizing transformer efficiency in power circuits. Ideal and actual characteristics, frequency limitations. Transformers: principles, operation, technology, constraints, performance, limitations, modeling, and sizing.
Compactness of magnetic components: increasing the switching frequency, minimizing losses to reduce the surface area required for heat dissipation, optimizing the converter topology. The merit factor of materials.
Magnetic materials for power electronics and their optimal frequency range. Eddy current losses. Different types of magnetic circuits. Amorphous materials, nanocrystalline materials, nature of ferrites; advantages of low-permeability materials in the manufacture of inductors. Litz wire. Multilayer PCB technology. Influence of the choice of converter on the dimensions of the transformer.

CAPACITOR TECHNOLOGIES 0.25 day

This course presents the different types of capacitors, their characteristics and their applications in power electronics. Participants will study the critical specifications for filtering, decoupling and energy storage applications. Ideal and actual characteristics, frequency limitation. Capacities: principles, operation, technology, constraints, performance, limits, modeling and sizing.

SEMICONDUCTOR TECHNOLOGIES AND THEIR PACKAGING 0.25 day

This course focuses on semiconductor technologies, including manufacturing processes and packaging techniques.
Participants will learn how packaging influences the thermal and electrical performance of components. Static characteristics, switch state changes, switch classification (2, 3, and 4 segments), diodes, transistors, component operating physics, and technologies.

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TD/TP PRINCIPLE OF CUTTING: CELL AND SWITCHING MECHANISMS 0.25 day

This practical course allows participants to apply the principles of switching and switching mechanisms in exercises and tutorials. They will build circuits to observe and analyze the operation of switching cells.

TD/TP BASIC TOPOLOGIES FOR DC-DC CONVERSION: OPERATING MODES 0.25 day

This practical course allows participants to test different DC-DC conversion topologies, observing their performance and operating modes. Participants will apply theoretical concepts to analyze efficiency and stability parameters.

ELECTRICAL ARCHITECTURE AND PROTECTION (PART 1) 0.25 day

This course introduces the principles of electrical architecture and protection in power systems. Participants will discover the basic elements for designing reliable architecture and methods for protecting electronic circuits. Principles, use, and operation of wiring and connectors. Technologies and properties of wiring and connector technologies. Technical and economic constraints of electrical architectures. Industrialization and integration.

ELECTRICAL ARCHITECTURE AND PROTECTION (PART 2) 0.25 day

Following on from part 1, this course takes an in-depth look at architecture and protection concepts, with a focus on advanced protection systems against overvoltage, overcurrent, and short-circuit conditions. Fuses, relays, circuit breakers, spark gaps. Insulation measurement, leakage current measurement. Short-circuit detection.
Regulations. Protection of people and equipment. Operating principles. Technologies. Integration and examples of topologies in electrified vehicles where these components are used. Dimensioning. Technical and economic constraints. Industrialization and integration. Benchmarking and roadmap.

RELIABILITY OF ELECTRONIC SYSTEMS 0.25 day

This module covers the concepts of reliability in electronics, including methods for evaluating and improving the durability of components and systems. Participants will study degradation factors and testing techniques for predicting component life.

ELECTRONIC SYSTEM FAILURE 0.25 day

This course covers common types of failures in electronic systems, their causes, and methods for preventing or minimizing these failures. Participants will learn predictive maintenance and diagnostic strategies.

HV INSULATION AND INSULATING MATERIALS FOR ELECTRONIC SYSTEMS 0.25 day

This module covers the principles of high voltage (HV) insulation in electronic systems, as well as the different types of insulators used. Participants will learn the criteria for selecting insulators and their role in the safety of high voltage systems.

COOLING OF ELECTRONIC SYSTEMS 0.25 day

This course focuses on cooling techniques for electronic systems, including heat sinks, fans, and liquid cooling. Participants will learn about thermal challenges and solutions to ensure stable component performance. Sizing the cooling of power components. Calculating component losses, thermal modeling of components and coolers.
Thermal cycling and component durability: temperature profiles based on converter usage profiles: a system approach. Determining temperature specifications. Challenges of miniaturizing these components. Nature of thermal losses, sensitive areas, and risks. Global cooling modes: air, liquid (single-phase, two-phase); challenges. Examples of implementation.

MANUFACTURING PROCESS: PRINTED CIRCUITS AND PCB ASSEMBLY 0.25 day

This course covers the manufacturing process for printed circuit boards (PCBs) and component assembly. Participants will learn the steps involved in PCB design and assembly technologies to optimize circuit quality

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and reliability. Technologies, constraints, and limitations. Technical and economic constraints. Thermal and vibration behavior. Design rules: insulation distances, track thickness and length. Number of layers. Importance of printed circuit board routing for power electronics performance: impact on EMC and durability. Properties of technologies.
Technical and economic constraints. Industrialization and integration. Benchmarking and roadmap.

MANUFACTURING PROCESS: ASSEMBLY AND INTEGRATION TESTS 0.25 day

This course explores assembly and integration testing techniques for electronic systems. Participants will learn methods for verifying the integrity of connections and solder joints, as well as functional testing after assembly.

EXAM AND TUTORIALS 0.25 day

This final session assesses the knowledge acquired during the week. Participants will have the opportunity to apply the concepts studied in tutorials to reinforce their practical understanding of the topics covered.

Sessions

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Training - Hydrogen Combustion Engine

H2COMB-EN-P | Face-to-face only | 3 days

The aim of this training course is to improve participants to the basics of operating a hydrogen combustion engine

Level
Skilled

Public
Engineers and technicians wishing to understand the basic physics of a hydrogen combustion engine and the major issues involved.

Objectives
Attendees will be able to implement the following skills:

- Understand the general context of the hydrogen economy and hydrogen as a mobility fuel
- Explain the chemical characteristics of hydrogen that influence the mixing process, ignition and combustion
- Understand the impact of hydrogen chemistry on engine performance (efficiency, pollutants, power, torque and noise)

Pedagogical & technical resources

- LMS
- Quiz

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites
No prerequisites are necessary to follow this course

Responsable
IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ASYNCHRONOUS PROGRAM TO BE TAKEN BEFORE THE SYNCHRONOUS/CLASSROOM COURSE

INTRODUCTION TO HYDROGEN & HYDROGEN IN THE CONTEXT OF MOBILITY

Hydrogen tomorrow.
Hydrogen production.

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Hydrogen mobility context.
E-fuels.

SYNCHRONOUS/PRESENTIAL PROGRAM

HYDROGEN IN THE INDUSTRIAL AND ENERGY LANDSCAPE — 0.5 day

Hydrogen as an energy carrier: trends, challenges and potential.
Hydrogen and energy networks: gas networks, multivector networks, network flexibility.
Hydrogen as an energy storage medium.
Hydrogen and e-fuels.
Positioning hydrogen in relation to other energy carriers.
Prospects for hydrogen in the energy and economic world 2025-2040.

HYDROGEN PRODUCTION — 0.5 day

The “rainbow” of hydrogen (green, gray, blue, turquoise, yellow): classification, costs, orders of magnitude, advantages and limitations.
Overview of production methods: water electrolysis, hydrocarbon reforming, photosynthesis. Opportunities and prospects.
Limits of different processes and technological prospects.
Case study:

- Calculate the carbon intensity of different H2 production methods in [kg CO2 eq /kg H2 produced].
- Based on average vehicle efficiency, calculate consumption in [kg H2/100 km].
- Calculate the CO2 impact of an FCEV and an HEV (with an ICE H2) in [g CO2 eq /km] according to the means of H2 production.
- Conclude on the advantages and difficulties of the 2 technologies.

H2 COMBUSTION ENGINE — 1 day

Chemical characteristics of hydrogen that influence the mixing process, ignition and combustion.
Impact of hydrogen chemistry on engine performance (efficiency, pollutants, power, torque and noise).
Engine technologies and technological developments required for hydrogen combustion (injection, intake, combustion, aftertreatment).
Advantages and m disadvantages of hydrogen combustion.
Virtual visit to an H2 test bench.
In-session digital teaching activity.

FILLING - OVERFILLING — 0.5 day

H2 combustion engine filling functional requirements:

- Richness.
- Cooling: EGR use - Water injection - Crankcase ventilation.

Supercharging systems:

- Possible types of supercharging on a H2 combustion engine.
- Turbocharger operation and technologies.
- Architectures.

MODELING - SIMULATION — 0.5 day

GT SIMULATOR: effect of lambda on cooling and supercharging requirements.

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Training - Hydrogen for mobility

H2SPOC-EN-D

Distance only

12 hours

12 hours over 3 weeks

This course gives an overview to the participants about H2 context, and about the technical (functional & organic) H2 solutions for mobility

Level

Knowledge

Public

Engineers, managers and technicians who are familiar with the operating fundamentals of Powertrains

Objectives

Attendees will be able to implement the following skills:

- Understand the general context of hydrogen economy and hydrogen as a fuel for mobility
- Compare and analyse the advantages and drawbacks of a fuel cell vehicle, a hydrogen combustion vehicle, and an electric vehicle
- Identify and understand the evolution of H2 combustion engines and Fuel cells

Pedagogical & technical resources

Teaching aids:

- Videos, surveys, evaluations..
- Interactive approach
- Pedagogical activities to validate knowledge acquisition

Technical means:

- Provision of resources and tools for remote support: training platform (LMS)
- Computer resources required: a minimum bandwidth of 1.5 Mbps for a video quality in 720P. For Zoom you can consult the technical requirements by clicking on the link: https://support.zoom.us/hc/en-us/articles/201362023-System-Requirements-for-PC-Mac-and-Linux. For Teams you can consult the requirements by clicking on the link: https://docs.microsoft.com/fr-fr/microsoftteams/hardware-requirements-for-the-teams-app
- Technical support is provided by our training platform management team
- Our trainers provide pedagogical assistance in synchronous mode during the virtual classes. Participants' questions can also be formulated on the training platform and will be answered during the virtual classes

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites

No prerequisites are necessary to follow this course

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Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

HYDROGEN FOR MOBILITY CONTEXT AND PRODUCTION

Hydrogen tomorrow – Interview;
Hydrogen production.
Hydrogen mobility context.
E-fuels.
Webinar Q&A.

HYDROGEN INTERNAL COMBUSTION ENGINE

Chemical characteristics of hydrogen that influence the mixing process, ignition and combustion.
Impact of hydrogen chemistry on engine performance (efficiency, pollutants, power, torque and noise).
Engine technologies and technological developments necessary for hydrogen combustion (injection, intake, combustion, after treatment).
Advantages and disadvantages of hydrogen combustion.
Webinar Q&A.

FUEL CELL VEHICLES

Fuel cells architecture.
Fuel cells introduction.
Fuel cell electrochemistry.
Fuel cells system.
Fuel cells powertain management.
Fuel cells safety.
Fuel cells conclusion.
Webinar Q&A.

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Training - Hybrid & Electric Powertrains

HEGMP-EN-P | Face-to-face only | 4 days

This course provides knowledge on the new directions engine manufacturers are taking for individual cars' motion

Level
Knowledge

Public
Engineers and technical staff wishing to increase their knowledge of electric hybrid automotive powertrains

Objectives
Attendees will be able to implement the following skills:

- Draw up a state-of-the-art review of hybrid powertrains, incorporating the general context of hybridization and the different forms of hybridization in road vehicles,
- Identify the criteria for sizing batteries and electric motors suitable for hybrid vehicles,
- Specify the main features and key functional parameters of the components of hybrid architecture,
- Define the operation of a hybrid powertrain and the associated development constraints.

Pedagogical & technical resources

- One of our best-sellers.
- Interactive talks, based on real examples and components.
- It covers all main technical fields of hybrid powertrains.
- Orders of magnitude are clearly given.

Assessment of achievements

- Trainees are assessed throughout the training through practical application phases and interactions with the trainer
- A final on-the-spot evaluation may also be carried out at the end of the course and/or at the end of each module using tests designed to verify the learners' understanding and assimilation of the knowledge linked to the training objectives

Prerequisites
No prerequisites are necessary to follow this course

Responsable
IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

ELECTRIC HYBRID POWERTRAINS — 1 day

Factors leading to such technologies emergence (interest and stakes).
Two categories of hybrid architectures: serial, parallel.

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Parallel architectures.
Single shaft, reversible starter generator in the accessories drive (STT + Adex), full hybrid.
Dual shafts, hybrid wheels, power shunt (DR), n mode power shunt (DRnM).
Consumption improvement functions: Stop and Start, regenerative braking, energy optimization, consumption measurement method, performances comparison, pollution.
New units: combustion engine, electrical machine, inverter, converter, booster, battery.
Overview, technico-economic balance and conclusions.
Electric vehicles.

ON-BOARD ENERGY STORAGE SYSTEMS — 0.5 day

Electrochemical battery: operating principle, characteristics and performances of the different technologies (lead-acid, cadmium-nickel, hydrogen-nickel, lithium-ion, lithium-polymer).
Ultra capacitor: principles, performances.
How it is inserted into the vehicle.

POWER ELECTRONICS — 0.5 day

Power components: Mosfet, IGBT, ...
Power electronics structures: DC-DC, DC-AC converters, ...
Power characteristics, installation restrictions, thermal and vibratory aspects. Electro-magnetic compatibility.

ELECTRIC MOTOR — 0.5 day

Electric motor different technologies: operating principles, characteristics, performances, evolution.
Installation restrictions: compactness, cooling.
Examples of applications to vehicles.

SYSTEM OPERATION - MANAGEMENT PRINCIPLES — 0.5 day

How to manage electric motors and converters? Which physical principles for which result?
Main functions, secondary functions.

HYBRID PROPELLERS & ENERGY MANAGEMENT — 0.5 day

Energy flux and energy supervision.
Meaning for serial, parallel and serial/parallel hybrids.
Objectives and restrictions: consumption, pollution, state of charge management, regenerative braking, stop/start functions, thermal engine boost, drive approval.
Techniques: empirical controls, application to a series vehicle, improvements offered to empirical controllers, optimum controllers.
Synthesis and controllers validation: use of system models, off-line optimization methods and adaptation and optimization online.
Application examples to vehicles.

THERMAL MANAGEMENT — 0.5 day

Thermal management of electrical main components. Installation restrictions.

VEHICLE INSTALLATION — 0.25 day

Manufacturing process of a complete system: storage system and drive chain dimensioning.
Installation restrictions, passenger compartment cooling.

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Training - Sustainable Aviation Fuel - SAF

SAF-EN-P | Face-to-face only | 2 days

This training course deals with the different jet fuels that can replace fossil jet fuel with a view to reducing pollutant and CO2 emissions. It provides an overview of what can be considered in the choice of production schemes

Level

Expert

Public

Executives, engineers and technicians in the renewable industries, refining, trading in petroleum products or renewable fuels... concerned by the evolution of jet fuel quality, in relation to the technologies applied to aviation turbines

Objectives

Attendees will be able to implement the following skills:

- to know the certified SAF, their manufacturing and distribution ways
- understand the integration of SAF into conventional jet fuel production schemes

Pedagogical & technical resources

Interactive training with trainees

Assessment of achievements

Quiz

Prerequisites

No prerequisites are necessary to follow this course

Responsable

IFP Training instructors, with expertise in the field and trained in modern teaching methods adapted to the specific needs of learners from the professional world

Program

FOSSIL-BASED JET FUEL — 0.5 day

Origine and composition of fossil-based jet fuel through the process flow diagram in a refinery.
Main characteristics necessary for its use.
Air emissions from jet fuel combustion.

SAF-SUSTAINABLE AVIATION FUELS — 1.25 days

Context, Regulations and issues, general review of the different production sectors, environmental assessment from well to wheel.
Certification – taxation.
Main production routes certified or in the process of certification of SAF: hydrotreated vegetable oils, synthetic biojets, biological routes and e-fuel.

INTEGRATION OF SAFS IN THE REFINING INDUSTRIES — 0.25 day

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Modifications and adaptations: processes, storage, logistics.
Segregation of products and/or certificates.
Sustainability and Traceability.

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