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

To French entities : IFP Training is referenced to DataDock ; you may contact your OPCO about potential funding.
Please contact our disabled persons referent to check the accessibility of this training program : referent.handicap@ifptraining.com

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