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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