Modeling and Design and of electric machines for electrical for e-mobility

This course is dedicated to the numerical modeling of electrical machines using the finite element method. It gives training on windings design as well as analytical pre-design approaches for permanent magnet synchronous machines and Inductions machines.

Learning outcomes :

Have the basic knowledge of design of electrical machines

Acquire modeling methods for PM machines and Inductions Machines using finite element method.

Topologies of powertrains in electric transportation systems

Pre-requisites :

Basics on electric machines

Basics on electromagnetics

Basics on finite element modeling

Course content :

- Winding topologies of AC machines
- Modeling of windings and calculation of their harmonics using standard or systematic methods
- Modeling of e-motors with Finite Element Method (PM machines and induction machines)
- Analytical pre-design of electric machines (PM machines and induction machines)

All examples and specifications are in strong connection with powertrains in e-mobility

Training Sessions :

The training sessions serve as a starting point for an individual design project that continues with tutored personal work:

Professor(s)

Noureddine Takorabet

Teaching Methods

LEC. : 18h / SC : 12h / LAB. : 0h

Assessment

Reports of SC.

Personal project

Conventional Exam

Bibliography

LAPORTE B., Electrotechnique, Machines électriques tournantes, Collection Technosup, Ellipses, Paris 2003. ISBN 978-2-7298-3658-0.

BIANCHI N., Electrical Machine Analysis Using Finite Elements, Taylor & Francis. ISBN 0-8493-3399-7.

WALKER J.H. ., Large Synchronous Machines, Oxford Science Publications. ISBN 0-19-859365-3.

- Modeling and implementation of winding design aspects (winding factors calculations, spectral analysis of air-gap flux density, ...). Both distributed and fractional slot windings are considered. (4 hours)

- Modeling and design of magnet machines (1 session of 4 hours)

- Modeling and design of wound rotor machines (1 session of 4 hours)

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Electric Drive

The objective is to provide the basis for dynamic modeling of electrical machines. The principles of vector control are described for industrial variable speed drives. The design of the controllers and their robustness under industrial constraints for common applications such as electric propulsion and/or traction and high dynamic performance electric actuators are discussed.

Professor(s)
Farid Meibody-Tabar
Babak Nahid-Mobarakeh

Teaching Methods
LEC.: 18h / LAB.: 12h

Assessment
LAB report and written examination

Learning outcomes:

In-depth knowledge of variable speed drives for energy efficiency in industrial applications, variable speed drives for transportation systems (rail, electric vehicle, naval and aircraft).

Pre-requisites:

Modeling of electric machines (permanent-magnet synchronous machines and induction machines)

Linear control systems

Modern control

Course content:

- Scalar control of Permanent-Magnet Synchronous Machines (PMSM)
- Park model of PMSM
- Principles of vector control for PMSM
- Torque control strategy for PMSM
- Decoupling control
- Design of current control loop: objectives and constraints
- Time scales separation: slow modes and fast modes
- Design of speed control loop
- Introduction to Direct Torque Control (DTC)
- Park model of Induction Machines (IM)
- Principles of vector control for IM
- Torque control strategy for IM
- Field-Oriented Control (FOC) vs. Direct Torque Control (DTC)
- Simulations under MATLAB-Simulink
- Teaching Lab
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Bibliography

P. Vas, Vector control of AC machines, 1990.

W. Leonhard, Control of Electrical Drives, Springer, 2001.

B.K. Bose, Modern power electronics and AC drives, Prentice hall, 2002.

J.P. Louis, Control of Synchronous Motors, John Wiley & Sons, 2011.

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Microgrids for transportation systems

In this course, we introduce the study of power architectures dedicated to embedded microgrids for transportation systems

- AC and DC electrical microgrid generation including the dedicated power electronics, their dynamical modeling and the associated advanced control strategies

- Hybridization of sources (storage elements, multi generators, multi loads) and energy management strategies: classical centralized energy management and

Professor(s)

Serge Pierfederici

Jean-Philippe Martin

Teaching Methods

distributed control

- Dynamical stability analysis and microgrid stabilization
- Numerical simulations and practical implementations

Learning outcomes :

Ability to design and control a microgrid system.

Ability to study the dynamical stability analysis.

Knowledge of the energy management of a microgrid.

Pre-requisites :

Basic electric circuit network study.

Elements of power electronics.

Notions of control systems.

Course content :

Lectures

- AC and DC electrical microgrid generation including the dedicated power electronics, their dynamical modeling and the associated advanced control strategies (8h)
- Hybridization of sources (storage elements, multi generators, multi loads) and energy management strategies: classical centralized energy management and distributed control (8h)
- Dynamical stability analysis and microgrid stabilization (6h)

Numerical simulations and practical implementations

Short courses / practical work

- SC : dynamic stability analysis and stabilization (4h)
- PW : energy management control of microgrids (4h)

LEC. : 22h / SC : 4h / LAB. : 4h

Assessment

written examination and lab report

Bibliography

Nikos Hatziargyriou Microgrids: Architectures and Control (Wiley)

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Project

Personal or group work spread over one semester. The subject is proposed by the Professor who will supervise the student.

The objectives are to know how to conduct a research or industrial project over a period of several months, to find references to scientific documents related to the project and to conduct scientific monitoring.

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Professor(s)

Teaching Methods
Personal work and regular supervision
Weekly meetings

Assessment

Report and defence

French for Foreign Learners

The objective is to discover or reinforce your knowledge of the French language and culture . Classes will be taught in level groups.

Professor(s)
Stéphanie Gallaire

Teaching Methods
SC :24h

Assessment
Continuuous assessment

Learning outcomes :
Students should reach A1 leveal in the 4 language skills

Pre-requisites :
none

Course content :
Greetings, introduction, politeness, Present tense, -er verbs, numbers, telling the time, dates, food and drinks, feelings, talking about habits and hobbies, passé compose etc…

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Scientific Communication

This course focuses both on written scientific communication and oral scientific communication

Learning outcomes :
Students should be able to present their research project in 3 minutes with a single slide.+ submit an abstract

Pre-requisites :

Professor(s)
Stéphanie Gallaire
Céline Corringer
Terry Wagner

Teaching Methods
SC :15h

Assessment
Continuuous assessment
Final oral presentation + abstract

Students should have aminimum B2 level in Engish

Course content :

report writing, abstract writing, concise technical English

simplifying/rephrasing technical concepts, rapport building, impact techniques etc..

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