Course guide
820143 - EMDEE - Electrical Machines Design

Last modified: 14/06/2023

Unit in charge: Barcelona East School of Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Ramon Bargalló Perpiña

Others: Primer quadrimestre:
RAMON BARGALLO PERPIÑA - T11

PRIOR SKILLS

Differential and integral calculus. Numerical integration and derivation.
MAtrix analysis.
Fourier Methods.
Electromagnetics.
Electrical Machines 1 and 2.
Use of scientific calculator (HP 50G, CFX9950, other)
Use of MATLAB

REQUIREMENTS

ELectrical Machines 1 and 2.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Carry out calculations for the design of electrical machines.
2. Apply regulations and standards based on sound criteria.
3. Summarise information and undertake self-directed learning activities.

Transversal:
4. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
5. ENTREPRENEURSHIP AND INNOVATION - Level 3. Using knowledge and strategic skills to set up and manage projects. Applying systemic solutions to complex problems. Devising and managing innovation in organizations.

TEACHING METHODOLOGY

Expositive methodology for theory classes.
PBL for exercices classes.
Training on FE software on laboratory classes.

LEARNING OBJECTIVES OF THE SUBJECT

- -To do to the student a general scope in the field of electrical machines and drives. The main treated aspects are their modelling and design.
To put into practice the FE method to analyse and design electrical machines and apparatus
- Explain general rules and methods for size electrical machines.
- Explain the main characteristics for materials used in the electrical machines to obtain an optimal design (technical, economical, environmental, etc. criterions are used)

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	20.00
Hours large group	30,0	20.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Electrical machines modeling using electromagnetic equations.

Description:
MAxwell equations. Constitutive relations. Boundary conditions. 2D and 3D analysis. Symmetries. Numerical solution of Maxwell equations. FE method. Derived quantities. Flux distributions. fem determination. Parameter determination. Losses. Force. Torque.

Related activities:
Inductance analysis using FE software.
Actuator analysis usinf FE software.

Full-or-part-time: 13h
Theory classes: 5h
Laboratory classes: 3h
Self study : 5h

Windings for electrical machines

Description:
Basis: salient pole windings, slot windings, end windings. Phase windings.MMF and EMF. Fractional windings. Other windings.

Related activities:
Winding design for a AC machine. Analysis of MME and EMF.

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

General concepts and limitations in the design of electrical machines.

Description:
General expressions for torque. Standards. Scale laws. Flux constant and weakening field work of electrical machines.

Full-or-part-time: 16h
Theory classes: 6h
Self study : 10h

Optimal design methods.

Description:
Problem formulation. Restrictions. Solve methods. Examples.

Related activities:
Optimal design of an actuator.

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

Parameter and losses calculation

Description:
FE determination of: losses, emf, cogging torque, torque, inductance, resistance, capacitance, etc.

Related activities:
Transformer analysis.

Full-or-part-time: 15h
Theory classes: 3h
Laboratory classes: 2h
Self study : 10h

Heat transfer

Description:
Heat removal: conduction, convection, radiation. Thermal equivalent circuits. FE calculation of heat.

Related activities:
Thermal analysis of a transformer: steady state calculation, transient calculation.
Combined electromagnetic+thermal analysis.

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

Design process

Description:
General formulation for sizing electrical machines. Application to: asynchronous, synchronous and permanent magnet machines. Every course one or more detailed process design will be developed.

Related activities:
FE analysis of:
- asynchronous machine. Steady state characteristics
- synchronous PM machine. Torque-angle characteristic, cogging torque, EMF determinations.
- Radial forces. Noise analysis.

Full-or-part-time: 33h
Theory classes: 9h
Laboratory classes: 4h
Self study : 20h

Insulation of electrical machines

Description:
Insulation materials. Monitoring insulation. Statistical analysis. Predictive analysis

Full-or-part-time: 13h
Theory classes: 3h
Self study : 10h

title en9. Treball dels motors de corrent altern a velocitat variableglish

Description:
Context: modificació de velocitat en màquines d'altern. Característiques a velocitat variable.
- Variació de velocitat en la màquina asíncrona. Mètodes convencionals. Variació del nombre de pols. Variació de la tensió aplicada. Variació de la tensió i la freqüència. Màquina asíncrona doblement alimentada.
- Models generals per a l'estudi de la variació de velocitat en màquines de corrent altern: models amb alimentació per corrent. Variables de control. Dependència del rang de treball del flux, relació de saliència i corrent aplicat. Àmbits de treball a parell constant i a potencia constant. Màquines amb velocitat màxima finita i infinita.
- Màquina síncrona de pols llisos.
- Màquina síncrona de pols sortints.
- Màquina síncrona de reluctància.
- Màquina asíncrona alimentada en corrent.

Specific objectives:
Entendre les variables que intervenen en la variació de velocitat d'un motor i els límits del camp de treball.

Full-or-part-time: 6h
Theory classes: 4h
Self study : 2h

GRADING SYSTEM

Midterm test: 20%
Final test: 20%
Laboratory:20%
Homework exercicis+classe exercises: 20%
Homework project (design an electrical machines): 20%

EXAMINATION RULES.

Final test with open books. NO final reexam.

BIBLIOGRAPHY

Basic:
- Pyrhönen, Juha; Jokinen, Tapani; Hrabovcová, Valéria. Design of rotating electrical machines [on line]. Chichester: John Wiley & Sons, 2013 [Consultation: 04/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1414122. ISBN 9781118581575.
- Hamdi, Essam S. Design of small electrical machines. Chichester [etc.]: John Wiley & Sons, cop. 1994. ISBN 0471952028.
- Gieras, Jacek F.; Wing, Mitchell. Permanent magnet motor technology : design and applications. 3rd ed. Boca Raton [etc.]: CRC Press, cop. 2010. ISBN 9781420064407.

Complementary:
- Krishnan, Ramu. Switched reluctance motor drives : modeling, simulation, analysis, design and applications. Boca Raton [etc.]: CRC Press, cop. 2001. ISBN 0849308380.
- Bianchi, Nicola. Theory and design of fractional-slot pm machines. Padova: CLEUP, 2007. ISBN 9788861291225.
- Bianchi, Nicola. Design, analysis, and control of interior PM synchronous machines. Padova: CLEUP, 2004.