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820143 - EMDEE - Electrical Machines Design

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 709 - EE - Department of Electrical Engineering
Academic year: 2017
Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: Ramon Bargalló Perpiña

Others: Ramon Bargalló Perpiña

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

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- -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

Total learning time: 150h	Hours large group:	45h	30.00%
	Hours medium group:	0h	0.00%
	Hours small group:	15h	10.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

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Content

Electrical machines modeling using electromagnetic equations.

Learning time: 19h

Theory classes: 6h
Laboratory classes: 3h
Self study : 10h

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.

Windings for electrical machines

Learning time: 18h

Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

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.

General concepts and limitations in the design of electrical machines.

Learning time: 16h

Theory classes: 6h
Self study : 10h

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

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Optimal design methods.	Learning time: 18h Theory classes: 6h Laboratory classes: 2h Self study : 10h

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

Related activities:
Optimal design of an actuator.

Parameter and losses calculation	Learning time: 15h Theory classes: 3h Laboratory classes: 2h Self study : 10h

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

Related activities:
Transformer analysis.

Heat transfer	Learning time: 18h Theory classes: 6h Laboratory classes: 2h Self study : 10h

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.

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Design process	Learning time: 33h Theory classes: 9h Laboratory classes: 4h Self study : 20h

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.

Insulation of electrical machines	Learning time: 13h Theory classes: 3h Self study : 10h

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

Qualification system

Final test: 20%
Laboratory:20%
Homework exercicis+classe exercises: 20%
Homework project (design an electrical machines): 40%

Regulations for carrying out activities

Final test with open books. NO final reexam.

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Bibliography

Basic:

Pyrhönen, Juha; Jokinen, Tapani; Hrabovcová, Valéria. Design of rotating electrical machines. Chichester: John Wiley & Sons, 2008. ISBN 9780470695166.

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. 2nd ed. New York: Marcel Dekker, cop. 2002. ISBN 0824707397.

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. [S.l.]: CLEUP, 2007. ISBN 8861291228.

Bianchi, Nicola. Design, analysis, and control of interior PM synchronous machines. CLEUP, 2004.