Course guide
240IEL32 - 240IEL32 - Design of Electric Machines and Electric Drives

Last modified: 16/05/2023

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

Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** Catalan

LECTURER

Coordinating lecturer: PERE ANDRADA GASCON

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEEELEC2. Calculate and design machines and electric actuators, with suitable knowledge on the efficient management of electrical systems and effective control of electrical actuators.

TEACHING METHODOLOGY

In the theory classes, the lecture method will be used combined with the participatory lecture class.
In the problem classes, the participatory lecture class will be combined with solving exercises and problems and problem-based learning
In the computer simulation practical classes, case studies will be combined with cooperative learning

LEARNING OBJECTIVES OF THE SUBJECT

Introduce to electric drives using a modern perspective, based on power electronics and control systems, which provide a solid theoretical basis and at the same time, enables the selection of control equipment suitable for each application. Initiate in calculation and design of electrical machines following a systematic and rational process, based more in-depth study of the common characteristics than in the calculation of the different types of electrical machines. Provide the basis for finite element analysis of electric machines.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	24.00
Self study	72,0	64.00
Hours small group	13,5	12.00

Total learning time: 112.5 h

CONTENTS

TOPIC 1.- Overview about electric drives

Description:
1.1- Drives. Definition and types.
1.2.- Dynamics of motor-load system. Mechanical considerations
1.4.- Power electronics and electrical machines.
1.5.- Current and position / speed sensors.

Full-or-part-time: 18h 30m
Theory classes: 5h
Laboratory classes: 1h 30m
Self study : 12h

TOPIC 2.-Basic principles of design of electric machines

Description:
6.1- Procedures for calculating electric machines and electrical drives
6.2.- Constructive aspects (standardization / regulations)
6.3.- Parametric equations of torque, power and voltage of rotating electrical machines
6.4.- Sizing of rotating electrical machines
6.5.- Scaling laws in electrical machines

Full-or-part-time: 12h
Theory classes: 4h
Self study : 8h

TOPIC 3.- Materials

Description:
2.1.- Conducting materials.
2.2.- Insulation materials.
2.3.- Magnetic materiales.
2.4.-Other types of materials.

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

TOPIC 4.- Magnetic circuits

Description:
4.1.- Magnetic circuits with magnetization currents.
4.2.- Magnetic circuits with permanent magnets.
4.3.- Flux leakage.
4.4.- Calculation of specific leakage permeances in electric machines.

Full-or-part-time: 19h 30m
Theory classes: 6h
Laboratory classes: 1h 30m
Self study : 12h

TOPIC 5.- Windings.

Description:
5.1.- Windings, fundamental principles.
5.2.- Armature windings of alternating current machines.
5.3.- Different types of armature windings of alternating current machines.
5.4.- Winding factors.
5.5.- Squirrel cage. Phase resistance of a squirrel cage.
5.6.- Phase resistance of an armature winding of alternating current.
5.7.- Armature winding of direct current machines. Different types of windings. Resistance of a direct current armature winding.
5.8.- Exitation windings. Resistance of an excitation winding.

Full-or-part-time: 17h 30m
Theory classes: 6h
Laboratory classes: 1h 30m
Self study : 10h

TOPIC 6. Losses and heating/cooling of electric machines

Description:
6.1.- Losses, basic principles.
6.2.- Iron losses.
6.3.- Copper losses.
6.4.- Mechanical lossses.
6.5.- Thermal considerations. Heating/cooling of electrical machines.
6.6.- Thermal circuits.

Full-or-part-time: 12h
Theory classes: 4h
Self study : 8h

TOPIC 7.- Introduction to finite element calculation of electric machines

Description:
7.1- Determination of electromagnetic fields in electrical machines
7.2.- Introduction to numerical calculation methods.
7.3.- Examples of application.

PRACTICAl WORK 1.- Programs of analysis of machines and electrical devices with finite elements: introduction to the FEMM program
PRACTICAL WORK 2.- Simulation with finite elements of a c.c. with permanent magnets.
PRACTICAL WORK 3.- Design of an electric driver for light electric vehicle

Full-or-part-time: 27h
Laboratory classes: 9h
Self study : 18h

GRADING SYSTEM

The final grade will be obtained according the following formula:

FINAL GRADE =max(N1,N2)
With:
N1 = 0.25*MARK OF FIRST TEST + 0.15* MARK OF PRACTICAL WORKS + 0.15 *MARK OF ASSESSMENT EXERCICES + 0.45 *MARK OF FINAL TEST

N2 = 0.15* MARK OF PRACTICAL WORKS + 0.15 *MARK OF ASSESSMENT EXERCICES + 0.70 *MARK OF FINAL TEST

If the final grade is less than 5, then there is the "REAVALUACIÓ" TEST, therefore the final grades will be obtained according the followiing formulas:

Final grade = màx (N1,N2)

N1 = 0.25*MARK OF FIRST TEST + 0.15* MARK OF PRACTICAL WORKS + 0.15 *MARK OF ASSESSMENT EXERCICES + 0.45 *MARK OF "REAVALUACIÓ" TEST

N2 = 0.25*MARK OF "REAVALUACIÓ" TEST + 0.15* MARK OF PRACTICAL WORKS + 0.15 *MARK OF ASSESSMENT EXERCICES

The mark of "reavaluació" test substitues the mark of the final test and/or the mark of the first term. The practical works and assesment exercices are not object of "reavaluació"

EXAMINATION RULES.

The three tests will be written and individual (a three-page form may be taken to the tests). The problems and questions of the final test and the re-evaluation will be mainly the syllabus done in class. It is allowed to use a scientific calculator. It is not permitted to use laptops of any kind, tablets, smartphones, and the like.

BIBLIOGRAPHY

Basic:
- Filizadeh, S. Electric machines and drives : principles, control, modeling and simulation [on line]. Boca Raton, FL: CRC Press, 2013 [Consultation: 03/02/2022]. Available on: https://www-taylorfrancis-com/books/mono/10.1201/9781315169651/electric-machines-drives-shaahin-filizadeh. ISBN 9781439858073.
- Fraile Mora, Jesús ; Fraile Ardanuy, J. Accionamientos Eléctricos. Madrid: Garceta, 2016. ISBN 9788416228492.
- Pyrhönen, J.; Jokinen, T.; Hrabovcova, V. Design of rotating electrical machines [on line]. 2nd ed. Chichester: John Wiley & Sons, 2013 [Consultation: 23/09/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1414122. ISBN 9781118701621.
- Jufer, Marcel. Electric Drives : Design Methodology. New York: Wiley, 2010. ISBN 9781848212176.
- Sul, Seug-Ki. Control of Electric Machine Drive Systems. New York: IEEE-Wiley, 2011. ISBN 9780470590799.