Universidad de Navarra

Electric Drives (Ing.Gr.)

Teaching guide 2025-26

INTRODUCTION

If the 21st century is characterised by anything, it is the widespread electrification that is taking place in many sectors of society. As far as cars are concerned, 100% of manufacturers' launches incorporate an electrified version in their current portfolio.

Alongside electric vehicles, there are also other applications in which motors are being introduced on a massive scale: drones, bikes, trucks, buses, aeroplanes...

A good electrical engineer must be familiar with the different types of existing electric motors, in order to apply them correctly to each case that arises. In addition, is important to know the basic aspects of motor design: current density, qualities of materials to be used, types of existing cooling systems, etc.

This course offers the student the possibility of designing, calculating and constructing a complete electric motor. To this end, they will be introduced to the use of powerful calculation and design software.

This knowledge will be applied to the design, manufacture and assembly of a permanent magnet synchronous motor. Finally, the designed motor will be tested to determine the maximum power it is capable of transmitting.

- **Degree:** Electrical Engineering
  - **Number of Credits**: 6 ECTS
- **Year**: 4.º curso, 1.º semester
- **Type of course:** Required
- **Language**: **English**
- **Lecture schedule:**

Instructors:

- Ph.D. Elosegui Simón, Ibon
- Pd.D. Martínez-Iturralde Maiza, Miguel
- Macayo Redondo, José Francisco

LEARNING OUTCOMES (Competencies)

ELECTRIC ENGINEERING

CG10 - Capacidad de trabajar en un entorno multilingüe y multidisciplinar.

CE19 - Capacidad para el cálculo y diseño de máquinas eléctricas.

CE20 - Conocimientos sobre control de máquinas y accionamientos eléctricos y sus aplicaciones.

CE26 - Conocimiento de los principios de la regulación automática y su aplicación a la automatización industrial.

PROGRAM

Universidad de Navarra

Course structure

The course is divided into two parts: a theoretical part and a practical part.

- In the **Practical Part**, the design, manufacture and testing of a permanent magnet synchronous motor will be carried out. In order to carry out this design, modern motor calculation software will be used.
- In the **Theoretical Part**, the necessary knowledge to carry out a good motor design will be offered.

Theoretical Part - Lessons

The topics of the course are as follows:

- **Lesson 1.** General introduction to PMSM motors
- **Lesson 2.** Electromagnetic and thermal design aspects of PMSM motors
- **Lesson 3.** Materials used in the machines
- **Lesson 4.** Types of windings
- **Lesson 5.** Cooling systems used in Electrical Machines
- **Lesson 6.** Control of electrical machines
- **Lesson 7.** Electrical machine manufacturing processes
- **Lesson 8.** Tests to carried out on electrical machines

Practical Part - Task

The following is the schedule to be carried out for the design, manufacture, assembly and testing of the motor to be designed.

Planing.JPGDetails of the work to be carried out in each of the tasks are given below:

- **Electromagnetic and thermal desing.** Starting from a given geometry, a permanent magnet synchronous motor will be designed, defining: winding, rotor geometry, magnets... as well as the performance obtained from the design. In addition, the corresponding manufacturing drawings will be defined.
- **Motor Manufacturing.** Once the geometry has been defined, the Tecnun's workshop will carry out the manufacture of the parts required for the designed motor.
- **Motor Assembly.** The stator shall be wound and the designed motor assembled for further testing.
- **Motor Testing.** Once the motor has been assembled, the relevant tests will be carried out for its characterization. In this process, the results obtained in the simulations shall be compared with those obtained in the tests.

Do you want to see what the students did last year in the course? click on the link...

EDUCATIONAL ACTIVITIES

I. Classroom teaching activities

1. Lectures

Universidad de Navarra

Lectures are given by the professor on the themes indicated in the syllabus with the help of the blackboard, power point presentations, videos and animation movies. The professor will post on ADI the power point presentation, the notes for each topic and some recommendations for futher reading.

2. Seminars (Required by the students)

They include:

- Responses to students' questions by the professor and classmates.
- Presentation by the professor of current scientific issues related to the course.
- Learn the operation of other types of machines that are not included in this course.

3. One-to-one tutorials

Each student may have personal interviews with the professor to help him/her with personal study and learning.

4. Evaluation

Exams to assess the successful accomplishment of the objectives.

II. Personal work

Students must understand themes covered early in the course to be able to comprehend information presented later in the course, and will have to be able to integrate material learnt throughout the course. Therefore, it is important that they do not fall behind and try to set aside regular times outside of class to work on the course material on a daily basis.

1. Students must read the assigned reading for a subject before the lecture covering that topic. Being familiar with topics beforehand will allow students to get the most out of the lecture.
2. Students should conduct personal study using the professor’s notes, notes taken in lectures and recommended books if needed.

III. Visits to companies

During the course visits will be made to two companies involved in the manufacture of electric motors.

This visit will allow students to see first-hand the processes of design, manufacture and testing of real electric motors.

IV. Credits/hours distribution of the activities. 6 ECTS = 150 h (25 h/ECTS)

1. Lectures 1.6 ECTS 40 h (26.7 %)

2. Seminars 0.6 ECTS 15 h (10.0 %)

3. Evaluation 0.16 ECTS 4 h (2.6 %)

Total classroom activities 2.4 ECTS 59 h (40 %)

4. On-to-one tutorials 0.04 ECTS 1 h (0.7 %)

5. Personal work 3.6 ECTS 90 h (60 %)

_____

Total 6 ECTS 150 h (110 %)

ASSESSMENT

ORDINARY CALL

As explained in the introduction to the course, the subject consists of a theoretical part and a practical part, both of which are assessed.

The subject has two parts on the basis of which it will be evaluated at the end of the course:

1. Practical: The practical part in turn consists of two parts:

a) Design, Manufacture and Testing of a Permanent Magnet Synchronous Motor.

b) Control of an Electric Motor

2. Theoretical: throughout the course, different theoretical aspects of motor design will be presented.

The **distribution of points** is according to the following table.

Task	Final Score [%]
Report 1 - Design, manufacture and test a Permanent Magnet Synchronous Motor (PMSM)	40
Report 2 - Optimization of PMSM	25
Report 3 - Control Design of a PMSM	25
Company visit reports	10

Universidad de Navarra

The following is an explanation of what each of the above **activities consists of:**

- **Report 1:** In the practical part of the course, the design, manufacture and test of a permanent magnet synchronous motor will be carried out. The Motor Cad software package will be used to carry out this task. **This work will be carried out in group.**
- **Report 2:** This time you will be given the specifications of a bus electric motor application. You will have to size and design a motor that meets the required specifications. **This work will be carried out in group.**
- **Report 3**: They shall design and simulate a Permanent Magnet Synchronous Motor control system using Simulink software. **This work will be carried out in group.**
- **Company visit reports:** Each student will send a report of no more than two pages indicating those aspects of the visit that most attracted his or her attention. The report will include the questions asked during the visit and the answers given by the company's technicians. **The report should be sent one week after the visit.**

An **additional mark** will be awarded if the student carries out any of the following activities:

- Class participation: 0.5 points
- Oral presentation of an inventor or electrical product: 0.5 points

EXTRAORDINARY CALL

- **Final Exam:** A final exam with the concepts explain in the semester. 100 % of the final score of the course.

OFFICE HOURS

According to the student´s need, contact the teacher

- **Dr. Ibón Elósegui (ieloseguis@unav.es)**
- **Dr. Miguel Martinez-Iturralde (mmiturralde@unav.es)**

BIBLIOGRAPHY

Basic

- ELECTRICAL MACHINERY, Fitzgerald, A.E. Kingsley, C., Ummans, S.D. McGraw-Hill, 2004.Localízalo en la biblioteca
- ALTERNATING CURRENT MACHINES, Say, M.G., Pitman. 5ª Ed.,1983. Localízalo en la biblioteca
- MÁQUINAS ELÉCTRICAS ROTATIVAS, Garcia Rico. A. Escuela Superior de Ingenieros Industriales de San Sebastián,1990.
- MÁQUINAS ELÉCTRICAS, Chapman, S.J. McGraw-Hill, 2005. Localízalo en la biblioteca

Specific

- ANALYSIS OF ELECTRICAL MACHINERY AND DRIVE SYSTEMS, Krause, P. C. McGraw-Hill,2013. Localizalo en la biblioteca (formato electrónico)
- DIRECT CURRENT MACHINES, Say, M.G., Pitman,1980. Localízalo en la biblioteca
- STEPPING MOTORS AND THEIR MICROPROCESSOR CONTROLS, Takashi Kenjo. *Oxford Science Publications* Localízalo en la biblioteca
- ELECTRIC MOTORS AND THEIR CONTROLS, T. Kenjo. *Oxford Science Publications* Localízalo en la biblioteca
- PERMANENT-MAGNET AND BRUSHLESS D.C. MOTORS, T. Kenjo and S. Nagamori. *Oxford Science Publications* Localízalo en la biblioteca
- BRUSHLESS PERMANENT MAGNET AND RELUCTANCE MOTOR DRIVE, Miller,T. J. *Oxford Science Publications* E. Localízalo en la biblioteca
- SWITCHED RELUCTANCE MOTORS AND THEIR CONTROL, Miller,T. J. E. *Oxford Science Publications* Localízalo en la biblioteca
- ELECTRICAL MACHINES AND DRIVES, Vas P. *Oxford Science Publications* Localízalo en la biblioteca
- VECTOR CONTROL OF ELECTRICAL MACHINES, Vas, P. *Oxford Science Publications*
- SPIRAL VECTOR CONTROL THEORY OF A.C. CIRCUITS AND MACHINES, Yamamura, S. *Oxford Science Publications* Localízalo en la biblioteca