

## Course guide

### 220613 - 220613 - Drive Control and Electric Drive Train

**Last modified:** 11/04/2025

**Unit in charge:** Terrassa School of Industrial, Aerospace and Audiovisual Engineering  
**Teaching unit:** 710 - EEL - Department of Electronic Engineering.

**Degree:** MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Optional subject).

**Academic year:** 2025    **ECTS Credits:** 5.0    **Languages:** English

#### LECTURER

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**Coordinating lecturer:** José Luis Romeral Martínez

**Others:** José Luis Romeral Martínez  
Juan Antonio Ortega Redondo  
Antoni Garcia Escudero

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

1. Research, design, development and implementation of new energy control and optimization technics in electronics for automobiles and industry.
2. Research, design and development of new electric traction motors and drive chain design and control. Charge strategies of electric drives.

**Transversal:**

5. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
6. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

**Basic:**

3. Improve technical communication of results.
4. Improve self-learning capacity

#### TEACHING METHODOLOGY

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The subject is divided into:

- Classes in large groups where theoretical is developed. Explaining (lecturing) method is used by the teacher to give spoken explanations of the subject that is to be learned. Visual aids power point supported are used to help students visualize the concept or problem.
  - Classes in medium size groups. In these classes apply theoretical knowledge explained in class theory or acquired by the student in their independent learning are applied to solve problems and practical examples. Collaborative students work is preferable in this Activity
  - Small Group Classes Instruction. It is done in the lab's Electronic Engineering Department, where students take contact with experimental equipment and methodology.
- ATENEA platform will be used as a support tool for all types of classes described above. The following flow of data will be established:
- Teacher - Students:
    - a. Information and programming activities.
    - b. Learning material.
    - c. Assessments of activities.
  - Student & Teacher:
    - a. Delivery of activities according to programmed rules.
    - b. Questions, comments and suggestions regarding the content of the material and learning.

## LEARNING OBJECTIVES OF THE SUBJECT

The main course objective is to introduce to Drive Motor Control, reviewing the fundamentals of speed & position motor control for different electric machines, and its applications as Electric Motor Drives for Electric Vehicles.

Flux and torque control are presented, as well as Four-quadrant motor operation and Energy Recovery. The basis of every motor drive structure is presented, and controls are compared each others.

Electric Vehicles configurations and technologies are introduced and discussed, and vehicle models are described, which are used to study the drivability and control of the electric Power Train.

MATLAB-Simulink simulations, Hardware in the Loop (HIL) structures and experimental workbenches are introduced and used during the training.

## STUDY LOAD

Type	Hours	Percentage
Hours small group	14,0	11.20
Self study	80,0	64.00
Hours large group	31,0	24.80

**Total learning time:** 125 h

## CONTENTS

### Module 1. Electric Motor Drives structures and operation. Electric Machines and Power Converters

#### Description:

The basis for motor drives structures is introduced, and components of the Electric Motor Drives are reviewed.

- 1.1 General Blocks of a Drive System
- 1.2 Load Torque/Speed Curves
- 1.3 Switching Power Electronics Converters for Drives
- 1.4 Basis for Electric Motors
- 1.5 DC Motors, AC Induction Motors, Synchronous Permanent Magnet Motors, Switched Reluctance Motors, Stepper Motors
- 1.6 Control Loops and Control Structures

**Full-or-part-time:** 6h

Theory classes: 2h

Self study : 4h

## Module 2. Review of Motors Models. Inductance Matrixes and Matricial Transformations

### Description:

Mathematical models of the motors are presented, as well as MATLAB/Simulink representations. Simulations are carried out, and results are discussed.

2.1 IM Model. The Space Phasor Model

2.2 Park's Transformation. Reference axes and physical meaning

2.3 Permanent Magnet Synchronous Motor (PMSM) model. Spatial Phasor and Park Transformations

2.4 Switched Reluctance Motor (SRM) model. Mathematical Model

### Related activities:

Practice 1: PMSM Motor Models and control. MATLAB simulations

**Full-or-part-time:** 23h

Theory classes: 6h

Laboratory classes: 2h

Self study : 15h

## Module 3. Electric Motor Control

### Description:

Scalar, Vector and Switching Motor Control are presented, for different motor types. Four-Quadrant and High Speed - Flux Weakening are presented too.

3.1 Scalar Control. Constant Volts per Hertz operation

3.2 Vector and DTC Control for an IM

3.3 Vector and DTC Control for a PMSM

3.4 Electronic Control for a SRM

3.5 Four Quadrant Operation and Energy Recovering.

3.6 Control at a High Speed. Flux Weakening.

### Related activities:

Practice 2: Vector and DTC Control of PMSM. HIL Experiments (DSpace and real motor/converters)

**Full-or-part-time:** 45h

Theory classes: 8h

Laboratory classes: 6h

Self study : 31h

#### Module 4. Automotive Electric and Electronic Systems. Electric Motor Traction and subsystems (6)

**Description:**

This Module introduces to Electric Vehicles configurations, highlighting electric and electronics parts related to Electric Motion.

- 4.1 Electric Machines and Application for Automotive
- 4.2 Electric Drivetrain systems: Serial, Parallel and Hybrid. In-Wheel Motors
- 4.3 Superimposition torques and steering intervention
- 4.4 Energy Storage for Hybrid and Electric Vehicles
- 4.5 Power Electronics and Charging Infrastructure for EV/PHEV

**Related activities:**

Practice 4: PSAT Guide: Electric Vehicle Configurations & Parallel vs Serial Configurations

**Full-or-part-time:** 22h

Theory classes: 6h

Laboratory classes: 2h

Self study : 14h

#### Module 5. Automotive Electric and Electronic Systems. Electronic Controls and Data Buses (6)

**Description:**

Electronics and electronics parts for managing and control Electrical Drives and Electric Subsystems in Electric Automobiles are presented and discussed.

- 5.1 Electronic ECUs and data communications
- 5.2 Battery Management Systems (BMS) and energy storage safety
- 5.3 Sensors, estimators and observers for EV dynamics control
- 5.4 Real-time control strategy development. Drivability and Energy Management
- 5.5 Infrastructure communications. DSRC and PLC

**Related activities:**

Practice 5: EV Energy Management and Electric motor design exercise

**Full-or-part-time:** 26h

Theory classes: 6h

Laboratory classes: 4h

Self study : 16h

#### Exams

**Description:**

A set of questions or exercises testing knowledge or skill will be asked to students in this Activity.

**Full-or-part-time:** 3h

Theory classes: 3h

## ACTIVITIES

### THEORY

**Description:**

The content of the course follows the class exhibition participatory model.

Subject's contents are exposed and discussed, whereas the teacher asks the students a series of questions related to material, applications, or future prevision of technology. New occurring questions can be introduced and discussed as lecture materials, following the news or technologies that can be of actual interest.

This activity is evaluated with the completion of two written tests, following the programmed exams schedule in ETSEIAT.

**Specific objectives:**

The specific objective is to transmit and to teach the student with the basis of technology of electrical motor drives, especially applied to electric vehicles.

**Material:**

As supporting material, lecture notes and selected books and bibliography, as well as information collected by students, are to be used.

Recomended bibliography is:

- Electric and Hybrid Vehicles: Design Fundamentals, Second Edition / Edition 2 (Iqbal Husain). August 2010, Publisher: CRC Press. ISBN-13: 9781439811757

- Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition. Mehrdad Ehsani, Series: Power Electronics and Applications Series, 2009 by CRC Press. ISBN 9781420053982.

**Full-or-part-time:** 91h

Self study: 63h

Theory classes: 28h

### LABORATORY

**Full-or-part-time:** 31h

Self study: 17h

Laboratory classes: 14h

### EXAMS

**Full-or-part-time:** 3h

Theory classes: 3h

## GRADING SYSTEM

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Qualification

- NP1: First Exam Mark
- NP2: Final Exam Mark
- PCT: Practical Work Mark
- LAB: Laboratory Mark.

The overall grade is obtained from the following expression:

Overall grade =  $0,30 \text{ NP1} + 0,30 \text{ NP2} + 0,10 \text{ PCT} + 0,30 \text{ LAB}$

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.

If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

## BIBLIOGRAPHY

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### Basic:

- Husain, Iqbal. Electric and hybrid vehicles: design fundamentals [on line]. 2nd ed. Boca Raton: CRC Press, 2011 [Consultation: 14/07/2025]. Available on: <https://doi-org.recursos.biblioteca.upc.edu/10.1201/9781439894972>. ISBN 9781439811757.
- Ehsani, Mehrdad. Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design [on line]. 2nd ed. Boca Raton: CRC Press, 2010 [Consultation: 14/07/2025]. Available on: <https://doi-org.recursos.biblioteca.upc.edu/10.1201/9781420054002>. ISBN 9781420053982.
- Subject's teachers. Lecture Notes.