Course guide
240265 - 240AU121 - Power Electronics

Last modified: 08/07/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: MASTER'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2019). (Optional subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: JOSEP BORDONAU FARRERONS

Others: JOSEP BORDONAU FARRERONS

PRIOR SKILLS

Circuit Theory Knowledge: Kirchhoff's Laws, analysis of linear circuits with resistors, capacitors, and inductors in DC and AC.
Electronics Knowledge: basic components (diodes, transistors), analysis of electronic circuits.

REQUIREMENTS

Background in circuit theory and basic Electronics.

TEACHING METHODOLOGY

Regular lecture (theory and problems) combined with learning by doing (project-based learning) in the lab sessions.
Participation of industrial experts of the sector in the lectures or the lab sessions.

LEARNING OBJECTIVES OF THE SUBJECT

1. Design of Power Electronic Converters: This program focuses on preparing students for a technological career in the automotive sector, either combined with responsibilities as a product manager, technical director, or innovation director.

2. Analysis, Diagnosis, and Design of Automotive Power Electronic Systems: Students will learn to analyze, diagnose, and design power electronic systems specific to the automotive industry. Additionally, they will address real-world problems encountered in research and development laboratories, as well as in manufacturing.

3. Design, Development, and Use of Power Electronic Converters in the Automotive Sector: Students will acquire skills related to designing, developing, and applying power electronic converters within the automotive context.

During laboratory sessions, students take on the role of junior engineers in a power electronic converter design company. They work in groups, supervised by the professor, to design, simulate, assemble, and test a power electronic converter for an automotive application. The design challenges include minimizing costs, losses, and volume/weight. Finally, students present their designs and results, which are compared among different groups in the course.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	18.00
Hours small group	27,0	18.00
Self study	96,0	64.00

Total learning time: 150 h

CONTENTS

Power Electronics

Description:
1. Introduction to Power Electronics:
- Definition and block diagram of a typical system.
- Initial view of applications.
- General specifications.
- Overall analysis methodology.

2. Power Electronic Devices:
- Diodes.
- SCR, TRIAC, GTO.
- BJT.
- MOSFET.
- IGBT.
- Control circuits (drivers).
- Snubber circuits.

3. DC-DC Converters:
- Buck converter.
- Boost converter.
- Buck-boost and Cuk converters.
- Isolated topologies.
- Application in power supplies.
- Application in converters for automotive systems, especially electric vehicles (EVs) and hybrid electric vehicles (HEVs).

4. DC-AC Converters:
- Rectangular modulation, PWM.
- Single-phase.
- Three-phase.
- Multilevel.
- Applications in electric motor drives for EVs and HEVs.

5. AC-DC Converters:
- Line-commutated: single-phase, three-phase.
- Self-commutated.
- Applications in electric vehicle chargers.

6. AC-AC Converters:
- Concept of AC switch.
- Cycloconverter.
- Applications in specific AC loads and network adapters for battery chargers.

Specific objectives:
- Functioning of an R&D department and the role of a junior engineer.
- Real design challenge, with industrial specifications and considering fabricability.
- Challenge of making the power electronic system work in the laboratory ("learning-by-doing").
- Global vision of the application of power electronic converters in industry and in the use and management of electrical energy.
- Acquire methodologies for analyzing power electronic converters, both at the block level and in their internal structure.
- Simulation of power electronic converters.
- Knowledge of modulation and control of power electronic converters.
- Knowledge of modeling power electronic converters, to apply them in control systems.
- Design methodologies for power electronic converters.
- Industrial specification of power electronic converters.
- Definition of performance of power electronic converters, oriented towards an application.
- Technology associated with components:
- Electronic devices and driver circuits.
- Reactive components.

- Thermal dissipation systems.
- Prototyping techniques.
- Introduction to industrial design of converters.
- Modeling of parasitic elements in Power Electronics.

Related activities:
Lectures:
14 master classes on theoretical and laboratory contents
Material: Slides from the reference book:
Mohan, Undeland, Robbins, Power Electronics: Converters, Applications and Design. John Wiley & Sons, 3rd edition, 2003. ISBN: 978-0-471-22693-2
Large group/Theory: 2 hours per session

Problems:
8 sessions of application problems.
Material:
Prepared by the instructor, published on Atenea.
Medium group/Practicals: 2 hours per session

Laboratory:
6 laboratory sessions supervised by the instructor to design the proposed system in the subject: 12 to 48 V dc-dc converter for MHEV, optimizing cost, performance, and size.
Material: own resources on Atenea.
Small group/Laboratory: 2 hours per session

Full-or-part-time: 56h
Theory classes: 28h
Practical classes: 16h
Laboratory classes: 12h

GRADING SYSTEM

- Exam for the 1st half of the course 30% (short theory and laboratory questions, and one problem).
- Exam for the 2nd half of the course: 30% (short theory and laboratory questions, and one problem).
- Demonstration and laboratory work report: 40%.
- Subject reevaluation, if applicable:
- Comprehensive exam covering the entire subject: 60% (short theory and laboratory questions, and one problem).
- Validation of the laboratory component, if applicable: 40%.
- If validation is not applicable, a 4-hour laboratory exercise involving design, assembly, and experimental demonstration will be conducted and evaluated orally: 40%.

EXAMINATION RULES.

Theory and lab: no documentation, based in short questions.
Any documentation for the problem.
Dmonstration of the lab work is done showing the operation of the circuit assembled in the lab sessions.
In case of reevaluation, theory/lab and problem are done in the same circumstances. For the lab part, any documentation is permitted.

BIBLIOGRAPHY

Basic:
- Mohan, Ned; Undeland, Tore M; Robbins, William P. Power electronics : converters, applications, and design. 3rd ed. New York [etc.]: John Wiley & Sons, cop. 2003. ISBN 0471226939.

RESOURCES

Audiovisual material:
- Transparències del llibre de referència. Slides of the reference book

Other resources:
Work material for laboratory practices available at Atenea:
- Application note on chips for electronic power converters for automotive applications.
- Simulation program guide.
- Guide for capacitor selection in electronic power converters.