Universidad de Alcalá

Advanced Power Electronics

Máster Universitario en Ingeniería Electrónica
(Master in Electronics Engineering)

Universidad de Alcalá

Academic year: 2023/2024

First Term

GUÍA DOCENTE

Name of the course:	**ADVANCED POWER ELECTRONICS**
Code:	**202936**
Degree:	**Master in Electronics Engineering**
Department & Area of Knowledge:	**Electronics / Electronic Technology**
	Compulsory
ECTS credits:	**4,5**
Year & semester:	**1st year / 1st semester**
Teachers:	**View website** https://www.uah.es/es/estudios/estudios-oficiales/grados/asignatura/Electronica-de-Potencia-Avanzada-202936
Office hours:	**View website**
Modality:	**Blended learning**
Language Classes Offered:	**English (it is also offered in Spanish)**

1a. PRESENTATION

This course is part of the general subject “Electronic Control and Power” subject inside the Master in Electronics Engineering of the University of Alcala.
The course aims to focus on advanced aspects of power electronics that allow more specific subjects of specialization to be tackled with guarantees in the following four-month period and, also, to balance possible imbalances in the previous knowledge of the incoming students (as it presupposes at least preliminary knowledge of all the basic power converters). The course will have a practical focus on detailed analysis and synthesis of systems for highly efficient power processing.

1b. RESUMEN DEL CURSO

Esta asignatura forma parte de la materia Electrónica de Control y Potencia del Plan de Estudios del Máster en Ingeniería Electrónica de la UAH.
La asignatura pretende incidir sobre aspectos avanzados de electrónica de potencia que permitan abordar con garantías asignaturas más específicas de especialización en el siguiente cuatrimestre y equilibrar posibles desbalances en los conocimientos de los alumnos de entrada, en tanto en cuanto presupone un conocimiento, al menos preliminar, de todos los convertidores básicos de potencia. Tendrá un enfoque práctico sobre detalles de análisis y síntesis de sistemas para el procesamiento de potencia con alta eficiencia.

2. COMPETENCES AND LEARNING RESULTS

This course contributes to the acquisition of the Basic, General and Specific competences detailed below:

Basic Competences	
CB6	Having and understanding knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB7	Students should be able to apply their acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study.
CB10	Students should get the learning skills that will enable them to continue studying in a largely self-directed or autonomous manner.

General Competences	
CG2	Conceiving, designing, implementing and maintaining an electronic system in a specific application
CG3	Acquiring skills in understanding new technologies for use in electronic systems and their appropriate use and integration to solve new problems or applications.
CG6	Adopting the scientific method as a fundamental working tool to be applied both in the professional and research fields.

Specific Competences	
CE1	Ability to design electronic systems both at a conceptual level, based on specific specifications, and at a system level, using modeling and simulation tools, and at a subsystem level using, among other hardware description languages.
CE2	Having the knowledge of the capabilities of new analog, photonic and power electronic components to improve the performance of current systems or applications.
CE3	Ability to handle advanced tools, techniques and methodologies for the design of electronic and photonic systems or subsystems
CE4	Ability to design a device, system or application that meets given specifications, using a systemic and multidisciplinary approach and integrating the advanced modules and tools that are typical of the field of Electronics Engineering.
CE7	Ability to experimentally verify in the laboratory the compliance of a new electronic and photonic system with the required specifications after its design

CE9	Ability to identify merit factors and effective comparison techniques to obtain the best solutions to scientific and technological challenges in the field of Electronics Engineering and its applications.
CE10	Ability to apply optimization techniques for the development of electronic circuits and subsystems
CE11	Ability to perform effective information searches as well as identify the state of the art of a technological problem in the field of electronic and photonic systems and its possible application to the development of new systems
CE12	Knowing the current state of the art and future trends in some of the following areas: power electronics, control electronics, microelectronics and photonics
CE13	Ability to identify from a conceptual, and also a practical point of view, what are the main scientific and technological challenges in different applications of electronic systems, as well as in their integration and use

On the other hand, the expected learning outcomes with this subject are as follows:

RAP1. Strengthening advanced aspects, both theoretical and practical, of power converters.
RAP2. Deepening in the stages involved in the development of real control applications related to power conversion.

3. CONTENTS

The course includes the following contents:

Brief description of its contents:

Content Blocks	Total hours
Block 1. Introduction to advanced power electronics systems	• **12 hours**
Topic 1: Review of devices, basic converters and development trends	
Topic 2: Power analysis in non-linear and unbalanced systems	
Block 2. Systems for energy collection in autonomous sensor networks	• **6 hours**
Topic 3: Converters and supervisors for autonomous very low power supply.	

Block 3. Advanced power electronics converters	
Topic 4: Bi-directional and resonant DC/DC converters	• **24 hours**
Topic 5: Multipulse and PWM AC/DC converters	
Topic 6: Multilevel DC/AC converters	
Evaluation and group mentoring	• **3 hours**
TOTAL	**45 hours**

4. TEACHING AND LEARNING METHODOLOGIES - TRAINING ACTIVITIES

4.1. Distribution of credits (specify in hours)

Number of hours:	22,5h face-to-face or synchronous online + 22,5h online
Number of hours of the student's own work:	67,5 h
Total hours	112,5 h

4.2. Methodological strategies, materials and teaching resources

In the teaching-learning process, the following training activities will be carried out:

Training activities	Total Hours	Face-to-face Hours or synchronous online
Theoretical classes	17,5	9
Practical classes	2,5	2
Theoretical-Practical classes	10	3
Laboratory Practices	7,5	5
Individual and/or group Mentoring	12,5	1,5
Work in group	5	0
Individual work	50	0

Evaluation tests, self and co-evaluation.	5	2
Work in virtual or web tools (debates, chats, forums, etc)	2,5	0

Throughout the course, students will be offered activities and tasks so that they can experience and consolidate the concepts acquired.

In order to carry out the practices, in the part that requires face-to-face learning, the student will have a position in the laboratory with a computer and the necessary elements for the simulation and/or experimentation of power systems.

During the whole learning process of the subject, the student will have to make use of different sources and bibliographic or electronic resources, so that he gets familiar with the documentation environments that will be used in the research or professional field.

All this can be summarized in the use of the following teaching methodologies:

Teaching methodologies for the subject
In-class lectures by the professor with the support of computer and audiovisual media, in which the main concepts of the subject are developed and the bibliography is provided to complement the students' learning.
Reading of texts recommended by the professor of the subject: scientific/technical articles, reports, manuals, etc., either for later discussion in class or to expand and consolidate the knowledge of the subject.
Resolution of practical cases, problems, etc. posed by the teacher individually or in groups.
Preparation and presentation of works and reports individually or in groups.
Development of laboratory practices in spaces with specialized equipment.
Use of the Virtual Classroom as a synchronous (videoconference) and asynchronous (recordings) teaching tool, and as a tool for interaction and debate between teacher and students: forums, chat and e-mail.

5. EVALUATION: Procedures, assessment and grading criteria

Preferably, students will be offered a system of continuous assessment that has formative evaluation characteristics, so that it serves as feedback in the teaching-learning process by the student. To this end, the following procedures are established:

5.1 Evaluation Procedures

The proposed evaluation process is inspired by the continuous evaluation, although, according to the rules of the University of Alcalá, the student will be able to benefit from the final evaluation[1].

5.2. Evaluation Criteria

The Evaluation Criteria must take into account the level of acquisition of the competencies by the student. To this end, the following criteria are defined.

- C1: The student is capable of correctly solving problems related to the analysis and design of electronic power systems.
- C2: The student integrates the knowledge explained in the different topics of theory to be able to solve in a creative and original way the problems that are presented to him.
- C3: The student implements in practice electronic power systems that give solution to the problems posed by integrating the knowledge acquired, making use of the bibliographic resources, computer tools and laboratory material at their disposal.
- C4: The student is able to generate correctly written documentation, with a sufficient technical level, clear and precise about the work done in the laboratory.
- C5: The student exposes and defends in a clear and reasoned way his proposals for the resolution of the problems posed.

5.3. Evaluation instruments

Evaluation instruments to be applied:

1. Short questions of theoretical/practical aspects developed in the course containing the basic aspects of the subjects taught.
2. Longer questions concerning the design of power systems in the form of practical problems.

[1] Students will have a period of 15 days to request in writing to the Director of the EPS their intention to use the final assessment model, giving the reasons that they consider appropriate according to the regulations governing learning assessment processes (approved by the Governing Council on September 2021).

3. Laboratory practices. It consists of the design, simulation and/or implementation of practical applications of power systems. A report of the work done will be presented and defended individually.

The evaluation system of the acquired competences includes the following components:

Evaluation of the theoretical part (TP): 50%.
Partial test 1 with short questions and problems: 25%
Partial test 2 with short questions and problems: 25%
Evaluation of the practical part in the laboratory (PP): 50%

The overall grade of the course will be the grade weighted with the percentages indicated, provided that in each set of tests (theory and practice) at least 40% of the maximum grade has been reached.

5.4. Grading criteria

5.4.1. Continuous Assessment Model:

a) Ordinary Call. Students will be evaluated continuously by means of tests distributed throughout the academic period. The percentages of weight of such tests over the final grade as well as the relation between the criteria and instruments of evaluation of the subject are as shown:

Learning Results	Evaluation Criteria	Evaluation Instrument	Grade Weight
RAP1, RAP2	CE1, CE2, CE5	TP	50%
	CE3, CE4, CE5	PP	50%

A student will be considered to have participated in the teaching-learning process and therefore to have taken part in the ordinary call if he or she takes one of the programmed tests of the theoretical part (TP) or the practical part (PP).

Students will be considered to have passed the course if they achieve an overall weighted mark of 5 or more (out of 10) among all the grading instruments, having obtained a minimum mark in each of the parts (PT and PP) of at least 40% of the maximum mark.

b) Extraordinary Call. Those students who do not pass the ordinary call will have the right to an extraordinary call. The theoretical part will be evaluated by means of an exercise with questions and problems, and the practical part by means of a practical laboratory exam. The percentages of weight of such tests on the final qualification, as well as the relation between the criteria, evaluation instruments and the learning results of the subject are as fshown:

Learning Results	Evaluation Criteria	Evaluation Instrument	Grade Weight
RAP1, RAP2	CE1, CE2, CE5	TP	50%
	CE3, CE4, CE5	PP	50%

Students will be considered to have passed the course if they achieve an overall weighted grade of 5 or more (out of 10) among all the grading instruments, having obtained a minimum grade in each of the parts (TP and PL) of at least 40% of the maximum grade.

5.4.2. Final Evaluation Model:

Ordinary and Extraordinary Calls. Those students who opt for the final evaluation model, both in the ordinary and extraordinary call, must pass: the theoretical part through an exercise with questions and problems, and the practical part through a practical laboratory exam. The percentages of weight of such tests on the final qualification as well as the relation between the criteria, assessment instruments and the learning results of the subject are as shown:

Learning Results	Evaluation Criteria	Evaluation Instrument	Grade Weight
RAP1, RAP2	CE1, CE2, CE5	TP	60%
	CE3, CE4, CE5	PP	40%

Students will be considered to have passed the course if they achieve an overall weighted grade of 5 or more (out of 10) among all the grading instruments, having obtained a minimum grade in each of the parts (TP and PL) of at least 40% of the maximum grade.

6. BIBLIOGRAPHY

6.1 Basic Bibliography

- Documentation elaborated by the lecturers ot the subject.
- Manuals of equipment, instrumentation and software tools used in the Power Electronics laboratory
- Introduction To Modern Power Electronics (Third Edition), Andrzej M. Trzynadlowski. Ed. John Wiley & Sons, Inc, 2016.

- HIGH-POWER CONVERTERS AND AC DRIVES. Wu, Bin. 2006. Ed. IEEE Press and John Wiley Intersience. ISBN 10-0-471-73171-4
- Design, Control and Application of Modular Multilevel Converters for HVDC Transmission Systems. Kamran Sharifabadi, Lennart Harnefors, Hans-Peter Nee, Staffan Norrga, Remus Teodorescu. ISBN-10: 1118851560. Wiley 2016.
- High-Frequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain. Deshang Sha, Guo Xu. Editorial: Springer, 2019. ISBN-10: 9811302588.

6.2 Complementary Bibliography

- Fundamentals of Electrical Drives. André Veltman, Duco W.J. Pulle and Rik W. De Doncker. 2007 Springer. ISBN-10 1-4020-5503-X(HB).
- Instantaneous power theory and applications to power conditioning. Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Aredes. Wiley-Interscience a John Wiley & Sons, Inc., 2007.
- ECPE Workshop - New Technologies for Medium-Frequency Solid-State Transformers. February 2019, Lausanne Switzerland
- White Paper – RX100 Microcontroller Family Energy Harvesting for Low-Power Sensor Systems. David Squires, Squires Consulting; Forrest Huff, Renesas Electronics America Inc. Feb. 2015.
- Power Electronics Handbook (fourth edition). Edited by Muhammad H. Rashid, Ed. Butterworth-Heinemann (imprint of Elsevier), 2018.
- Fundamentals of Power Electronics. Robert W. Erickson, Dragan Maksimović. Springer Nature Switzerland AG 2020-. Third edition. ISBN: 978-3-030-43879-1.