Universidad Zaragoza

Academic Year/course: 2022/23

28826 - Power Electronics

Syllabus Information

Academic Year: 2022/23
Subject: 28826 - Power Electronics
Faculty / School: 175 - Escuela Universitaria Politécnica de La Almunia
Degree: 424 - Bachelor's Degree in Mechatronic Engineering
ECTS: 6.0
Year: 3
Semester: Second semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The general objective of the course is to provide the necessary knowledge to interpret and solve electronic power control circuits, especially in the areas of static switches, rectifiers, inverters, regulators and power inverters.

This requires the correct use of the most common computer applications, to obtain information on the power components and their applications, and also to correctly interpret the technical documentation of the components used; as well as computer applications for circuit simulation. The correct handling of the measuring and feeding devices commonly used in the electronics laboratory must also be achieved, as well as the proper interpretation of the measurements made.

The indicators that the objectives have been achieved will be: the ability to read plans of commercial electronic equipment and applications, and also the ability to make electronic schemes of the typical power output circuits and control elements, according to the appropriate regulations and symbols, and finally the realization of technical reports on the practical activities carried out.

These approaches and objectives are in line with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the course learning outcomes provides training and competence to contribute to their achievement to some degree:

- **4.4** By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.
- **4.7** By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture?s contribution to sustainable development.
- **9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
- **9.4** By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.
- **12.2** By 2030, achieve the sustainable management and efficient use of natural resources.
- **12.5** By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

1.2. Context and importance of this course in the degree

The subject of Power Electronics is part of the Degree in Mechatronic Engineering taught by EUPLA, within the Electricity and Electronics module. It is a subject of the third course located in the sixth semester and compulsory (OB), with a teaching load of 6 ECTS credits.

1.3. Recommendations to take this course

The development of the subject of Power Electronics requires putting into play knowledge and strategies, coming from subjects corresponding to the previous courses and semesters of the Mechatronic Engineering Degree, related to:

Mathematics, Physics, Chemistry, Technical Drawing, Computer Science, Electrical Engineering, Electronic Technology I and Electronic Technology II.

However, it is not a legal requirement to have passed them in order to join Power Electronics.

2. Learning goals

2.1. Competences

- **(EI05):** Knowledge of the fundamentals of electronics.
- **(EE06):** Applied knowledge of power electronics.
- **(EE07):** Ability to design electronic power systems.
- **(GI03):** Knowledge of basic and technological subjects that enable you to learn new methods and theories, and provide you with versatility to adapt to new situations.
- **(GI04):** Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of Industrial Engineering.
- **(GC02):** Interpret experimental data, contrast them with the theoretical ones and draw conclusions.
- **(GC03):** Capacity for abstraction and logical reasoning.
- **(GC04):** Ability to learn continuously.
- **(GC05):** Ability to evaluate alternatives.
- **(GC06):** Ability to adapt to the rapid evolution of technologies.
- **(GC07):** Ability to lead a team as well as being an active member of it.
- **(GC08):** Ability to locate technical information, as well as its understanding and evaluation.
- **(GC09):** Positive attitude towards technological innovations.
- (**GC10):** Ability to write technical documentation and present it with the help of appropriate computer tools.
- **(GC11):** Ability to communicate their reasoning and designs clearly to specialized and non-specialized audiences.
- **(GC14):** Ability to understand the operation and develop the maintenance of mechanical, electrical and electronic equipment and installations.
- **(GC15):** Ability to analyze and apply simplified models to technological equipment and applications that allow forecasting of their behavior.
- **(GC16):** Ability to configure, simulate, build and test prototypes of electronic and mechanical systems.
- **(GC17):** Capacity for the correct interpretation of plans and technical documentation.

2.2. Learning goals

- To explain the behavior of power semiconductor devices and their protection components, applying fundamental electrical laws and principles, using appropriate vocabulary, symbols, and forms of expression.
- To analyze and describe the operation of typical topologies, which are used in the electronic control of electrical power, justifying their operation using block diagrams, input-output wave graphs, equations, and transfer functions.
- To select and correctly use the components of a power electronic circuit, both in direct current and alternating current applications, and in these single-phase and three-phase applications, detailing their function in the block where they are used.
- To analyze and interpret diagrams and plans of applications and electronic power equipment, understanding the function of an element or functional group of elements in the set, based on existing regulations.
- To select and interpret adequate information to propose and assess solutions to common technical needs and problems in the field of Power Electronics, with a level of precision consistent with that of the various magnitudes involved in them.

- To choose and properly use the typical measuring devices in the Electronic Laboratory, assessing their field of application and degree of precision.
- To know how to use the general methodology and the appropriate software tools to work in Power Electronics applications.
- To identify the different power semiconductor components and the needs and criteria for their protection, which also requires the ability to interpret technical documentation: data sheets for electronic devices, device manuals, standards, regulations, etc.
- To know the handling of the main electrical measurement devices: voltmeter, ammeter, ohmmeter, wattmeter, oscilloscope, network and harmonic quality analyzers, physical magnitude meters of controlled machines (speed, temperature, etc.) and acquire skill in their use on practical assemblies.

2.3. Importance of learning goals

This subject is taught in the Electricity and Electronics module, is based on the so-called Electronic Technology I, focused on Analog Electronics, and Electronic Technology II focused on Digital Electronics (taught successively in the previous two semesters). With a good level in these bases, the student should not have difficulties to achieve good results in learning Power Electronics.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The evaluation of the subject contemplates the continuous evaluation system, as the most appropriate to be in line with the guidelines of the EHEA (Bologna agreements), regarding the degree of involvement and continued work of the student throughout the course.

In order for students to benefit from the continuous assessment system, they will need to attend at least 80% of the classes. The lack of assistance must be adequately justified.

The continuous evaluation system will culminate with the weighted sum of the grade obtained in each of the four blocks contained in the subject. The fourth block will consist of a volunteer work, qualified with an extra increase of up to 10% on the final grade:

FINAL NOTE = Block 1 (50%) + Block 2 (50%) {+ Block 4 (10%)}

The subject will be passed when in this weighted evaluation, a score equal to or greater than 5.0 points is obtained, taking into account that, to apply this weight, the minimum mark for each block of the subject will be 4.0 points. When the minimum is not reached in a single block, this average will not be applied and the student will be pending further evaluation. Prior to the first call, the teacher will notify each student whether or not they have passed the subject based on the level demonstrated in the continuous assessment system.

In case of not passing in this way, the student will have two additional calls to do so (global assessment test). The subject of the blocks that have not passed the minimum score of 4.0 will be compulsory, and the subject with higher score is optional, always under the responsibility of the student.

Type of tests and evaluation criteria:

For each of the indicated content blocks (unless expressly indicated), the types of activities described below will be controlled, applying the assessment criteria indicated:

- **Exercises, theoretical questions and proposed works:** Their approach and correct development, the writing and coherence of the treated will be valued, as well as the achievement of results and the final conclusions obtained. The qualification of the proposed theoretical-practical exercises will be taken into account.
- **Laboratory practices:** In each one of the practices the dynamics followed for its correct execution and operation will be valued, as well as the problems raised in its development. In the proposal of Tasks for each Practice Block (to be published in Moodle) the aspects of individual and group work to be carried out are indicated. The qualification of the report presented will assess whether the data required is correct and the questions asked have been answered correctly. The final grade for each block will be from 0 to 10. The suspended or not completed practices will be evaluated in a laboratory exam for which the appropriate dates will be enabled.
- **Written assessment test (for Blocks 1, 2):** It will consist of solving theoretical / practical questions and problems,

with reduced space for answers, where the student will demonstrate, through drawings, graphics, texts, equations and / or calculation, their mastery of the concepts worked on in each subject block. The mark of the partial block will be calculated as the average of the obtained in the topics covered. The qualification obtained in each test will suppose between 60% and 70% of the mark of the corresponding block, provided that the minimum mark of each block of the subject has been exceeded (4.0 points).

- **Individual activities in Moodle Forums (for Blocks 1, 2):** The active participation of the student will be taken into account, responding to the proposals made by the teacher in the corresponding forums.
- **Group activities in class (for Block 3):** This block will evaluate the defense and public exposure of the part of the subject assigned to each group of students as well as the technical report presented in this regard. Student participation will be **voluntary**.

The weighting of the qualification process, of the different activities, in which the continuous evaluation process of the subject has been structured will be as follows:

SECTIONS 1 and 2:

- Class activities, exercises and proposed work, Moodle activities: Maximum 20%.
- Laboratory practices: 30%.
- Written assessment tests: 50% -70%.

SECTION 3:

- Activity memory: 30%.
- Public defense of activity: 70%.

The percentages presented for all the blocks assume that the minimum mark (4.0 points) has been exceeded in each part of the subject: theory blocks 1 to 3 and the laboratory practices corresponding to each block.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The Power Electronics course is conceived as a set of contents, but distributed in three blocks, where it deals with concepts of operation of power components and their protection elements to power elements such as static switches, drives and regulators, rectifiers and power inverters.

The first two blocks will be dealt with under three fundamental and complementary ways: the theoretical concepts of each didactic unit, the resolution of problems or questions and practices, supported in turn by another series of activities such as tutorials and seminars and will be tested individually, regardless of the blocks.

The third block will have a different treatment because the students will work in groups only previously assigned sections, they will be able to express their preferences but all the subjects will have to be assigned to some group. They will prepare presentation materials and defend their work with a public presentation, which will be valued by the rest of the students and the teacher.

The teacher/student interaction is carried out in this way, through the distribution of work and responsibilities between students and teachers. However, it must be taken into account that, to a certain extent, students can set the pace of learning according to their needs and availability, following the guidelines set by the teacher.

The organization of teaching involves the active participation of the student, and will be carried out following the following guidelines:

- **Lectures:** Theoretical activities imparted in a fundamentally expositive way by the teacher, in such a way as to expose the theoretical supports of the subject, highlighting the fundamental, structuring the concepts and relating them to each other. If classroom teaching were not possible due to health reasons, it would be carried out on-line.
- **Practical lessons**: The teacher solves problems or practical cases for illustrative purposes. This type of teaching complements the theory explained in the lectures with practical aspects. If classroom teaching were not possible due to health reasons, it would be carried out on-line.

- **Seminars:** The total group of lectures or practical lessons may or may not be divided into smaller groups, as appropriate. They will be used to analyze cases, solve problems, etc. Unlike what happens with the practical lessons, the teacher is not a protagonist, simply listening, counselling, clarifying, evaluating, assessing. It seeks to encourage student participation, as well as making the continuous assessment of students possible and to learn about the performance of learning.
- **Lab Practice:** The total group of lectures will be divided into several shifts, according to the number of students enrolled, but never with more than 20 students per shift, so that smaller groups can be formed. Students will do assemblies, measurements, simulations, etc., in the laboratories in the presence of the teacher. If classroom teaching were not possible due to health reasons, it would be carried out on-line.

Practical activities are carried out in groups of two /three students per shift, although for the reports students of two or more shifts can be grouped. For each subject block, guidelines for practical tasks will be given (compulsory and optional); In addition, the reporting rules will be specified in a guidance document, which will be handed out at the beginning of the practical activities.

- **Group tutorials**: Programmed activities of learning follow-up in which the teacher meets with a group of students to guide their work of autonomous learning and supervision of works directed or requiring a high degree of advice by the teacher.
- **Individual tutorials**: These are the ones made through the individual attention of the teacher in the department. They aim to help solve the doubts that students come across, particularly those who for various reasons cannot attend group tutorials or need more personalized attention. These tutorials can be in person or virtual.

The approach, methodology and assessment of this guide are intended to be the same for any teaching scenarios. They will be adapted to the social-health situation at any particular time, as well as to the instructions given by the authorities concerned.

4.2. Learning tasks

The course includes the following learning tasks:

Generic on-site activities:

- **Lectures**: The theoretical concepts of the subject will be explained and illustrative practical examples will be developed as a support for the theory when it is deemed necessary.
- **Practical lessons**: Problems and practical cases will be made as a complement to the theoretical concepts studied.
- **Practical tasks**: Students will be divided into several groups of no more than 20 students, being guided by the tutorial action of the teacher.
- **Defense and presentation of topics:** on the particular contents that are assigned to each group of students, corresponding to Block 3**.**

Generic off-site activities:

- Study and assimilation of the theory explained in the lectures.
- Understanding and assimilation of solved cases in practical lessons.
- Preparation of seminars, solving suggested problems, etc.
- Participation in Forums of the subject via Moodle, to provide links of information on the Internet.
- Preparation and development of scripts and corresponding reports.
- Preparation of written continuous assessment tests, and global assessment tests.

Autonomous tutored activities: Although they will be done on-site, they have been taken into account separately because of their particular features, they will be focused mainly on seminars and tutorials under the supervision of the teacher.

Reinforcement activities: Off-site activities preferably, via the virtual portal of teaching (Moodle), will be designed to reinforce the basic contents of the subject. These activities can be personalized or not.

4.3. Syllabus

The theoretical contents are articulated based on three blocks (numbers 1 to 3). Each of the blocks is made up of weekly allocation topics, one for each of the weeks of the course, these topics contain the necessary contents for the acquisition of the predetermined learning results.

Theoretical contents:

Section 1: POWER SEMICONDUCTORS AND BASIC POWER SYSTEMS
1-. Power Diodes and Transistors
2-. Thyristor, TRIAC and other active components
3-. Protection, Association and Refrigeration
4-. A.C. and D.C. static switches.

Section 2: POWER AND MOTOR CONTROL
5-. Power Converters and Regulators
6-. Uncontrolled and controlled rectifiers
7-. Topologies and Inverter and Converter circuits
8-. Speed drives for electric motors

Section 3: APPLICATIONS OF POWER ELECTRONICS
9-. Temperature controls and heating
10-. Uninterrupted power supply systems (U.P.S.)
11-. Control Systems in Alternative Energies
12-. Other fields of application of Power Electronics

Practical contents:

Each Section exposed in the previous section has associated practices in this regard, either through practical assumptions and/or physical or simulated assembly work leading to obtaining results and their analysis and interpretation. As the topics are developed, these Practices will be proposed, preferably in the classroom and also through the Moodle platform.

Practices to be developed in the Laboratory are given below. They will be carried out by the students in one-hour sessions, except in the final practice, in which the three hours corresponding to Section 4 are accumulated.

PRACTICES Section 1

- **Exercise 1: Power Diodes and Transistors**
- **Exercise 2: Thyristor, TRIAC and others**
- **Exercise 3: Protection, Semiconductor Association, Refrigeration (proprietary software)**
- **Exercise 4: Static switches**

PRACTICES Section 2

- **Exercise 1: Power shifters**
- **Exercise 2: D.C. Regulators**
- **Exercise 3: Non-controlled Rectifiers**
- **Exercise 4: Controlled rectifiers**
- **Exercise 5: Variable speed drives in electric motors**

IMPORTANT: The content of theory and practices will be adapted to the time available, as well as to laboratory material.

4.4. Course planning and calendar

Temporary distribution of a teaching week:
The subject is defined in the Verification Report of the Degree with a low experimental grade so that the 10 hours a week are distributed as follows:

- **Theory-practical classes**: 3 hours a week (blocks 1, 2) / 5 hours per week (block 3).
- **Practice tasks**: 1 hour per week.
- **Other activities**: 6 hours per week (blocks 1, 2) / 4 hours per week (block 3).

Test schedule:
For the assessment tests, described in the continuous assessment process, the following schedule is suggested:

- **Test 1**: (Topics 1, to 4).
- **Test 2**: (Topics 5 to 8).

Speech-Presentation of Works:
Works of Block 3 (Other Power Electronics systems), will be orally tested during the three final weeks of the course, depending on the number of students and the specific development of the preparatory tasks.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=28826