Power electronics in energetics systems

Academic Year: (2023 / 2024) **Review date: 29/08/2023 11:29:58**

Department assigned to the subject: Electronic Technology Department

Coordinating teacher: BARRADO BAUTISTA, ANDRES

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 1

LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2. Apply computational and experimental tools for analysis and quantification of energy engineering problems
CG4. Being able to do design, analysis, calculation, manufacture, test, verification, diagnosis and maintenance of energetic systems and devices.
CG10. Being able to work in a multi-lingual and multidisciplinary environment
CE8 Módulo CRI. Knowledge and ability for systems modelling and simulation.
CE9 Módulo CRI. Knowledge of the fundamentals of automation and control methods and their application to industrial automation.
CE13 Módulo CRI. Know and use the main electronic components.
CE6 Módulo TE. Applied knowledge on power electronics.
CT1. Ability to communicate knowledge orally as well as in writing to a specialized and non-specialized public.
CT2. Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.
CT3. Ability to organize and plan work, making appropriate decisions based on available information, gathering and interpreting relevant data to make sound judgement within the study area.
CT4. Motivation and ability to commit to lifelong autonomous learning to enable graduates to adapt to any new situation.

By the end of this content area, students will be able to have:
RA1.3 A coherent knowledge of their branch of engineering including some at the forefront of the branch in power electronics.
RA2.1 The ability to apply their knowledge and understanding of power electronics to identify, formulate and solve engineering problems using established methods.
RA3.1 The ability to apply their knowledge and understanding to develop and realize designs to meet defined and specified requirements.
RA3.2 An understanding of design methodologies, and an ability to use them.
RA4.3 Workshop and laboratory skills.
RA5.1 The ability to select and use appropriate equipment, tools and methods.
RA5.2 The ability to combine theory and practice to solve problems of power electronics applied to energetic systems.
RA5.3 An understanding of applicable techniques and methods in power electronics, and of their

limitations.

OBJECTIVES

The goal of this subject is to provide the student with multidisciplinary and solid knowledge in every aspect involved in the design, selection, and operation of power converters and power electronics systems.

Along the subject, special attention will be paid to identify the most commonly used converter topologies, modulation techniques, control strategies, power semiconductor devices, and magnetic components, applied to transform the electrical energy.

In order to achieve this goal, the student will acquire the following specific skills:

- Ability to identify the best power semiconductor for each type of application.
- To know some converter topologies for each type of energy conversion: DC-DC, DC-AC y AC-DC.
- To know the figures of merit that drive the design and optimization of the power converters.
- To know the improvements and potential advantages of the most advanced topologies that are currently used in electrical energy conversion systems.
- Ability to develop the dynamic modeling of a power converter, from a practical point of view.
- Ability to design in practice the current control loop of a power converter. This control technique is used in most of the control systems of power electronics converters applied to energy conversion.
- To know the basic protection techniques and thermal management techniques used in power converters.
- To know how Power Electronics is an enabling technology in most of the current energy applications

By the end of this course, students will be able or will have:
- A coherent knowledge of their branch of engineering including some at the forefront of the branch in power electronics.
- The ability to apply their knowledge and understanding of power electronics to identify, formulate and solve engineering problems using established methods.
- The ability to apply their knowledge and understanding to develop and realize designs to meet defined and specified requirements.
- An understanding of design methodologies, and an ability to use them.
- Workshop and laboratory skills.
- The ability to select and use appropriate equipment, tools, and methods.
- The ability to combine theory and practice to solve problems of power electronics applied to energetic systems.
- An understanding of applicable techniques and methods in power electronics, and of their limitations.

DESCRIPTION OF CONTENTS: PROGRAMME

The subject is divided into three main blocks:

Block 1: Power Electronics applied to electrical energy production and management.
- Power supply systems in transportation. Railway, electric cars, aerospace.
- Power converters in renewable energy systems: Photovoltaics, wind power, wave energy.
- Uninterrupted Power Supplies.
- Energy recuperation systems.

Block 2: Components and topologies
- Review of basic electrical concepts and commonly used mathematical tools.
- DC-DC converters.
- Rectifiers (AC-DC).
- Inverters (DC-AC).
- Advanced topologies applied to energy conversion: multilevel converters and modular converters.
- Power losses and heat-sinks.
- Electrical protections.

Block 3: Control techniques in power converters.
- Dynamic modeling fundamental.
- Control loop design.

- Control of a grid-tied three-phase inverter.

LEARNING ACTIVITIES AND METHODOLOGY

The teaching methodology will include::

- Magisterial Classes (3 ECTS), where the students will be presented with the basic knowledge they must acquire. Students will be supplied with lecture notes and key reference texts that will enable them to complete and acquire a more in-depth knowledge of the subject.
- Problems Classes and Laboratory Classes (3 ECTS) are aimed at the solving of exercises and examples within the context of real case studies. These classes will be complemented with the resolution of practical exercises on behalf of the student that in some cases may require the use of computer-based simulation programs. The Laboratory classes will be developed taking into account a double methodology. In the first session, the student will design mount and measure a real DC-DC converter. In the next sessions, students will use the most convenient CAD tools applied to design and simulate power converters such as grid-tied inverters.
- Group tutorial: At least a group tutorial will be carried out during the recovery week as revision and final exam preparation.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

A continuous evaluation system will be carried out where the following will be evaluated:

1. Compulsory Laboratory Sessions (20%): The knowledge acquired by the student will be evaluated by means of the experimental implementation and simulation of several of the power converters analyzed previously in the Magisterial and Problems classes. The development of the laboratory sessions will be carried out in groups.

2. Solving problems and/or test questions proposed for each thematic block (20%). The resolution will be carried out individually.

3. Final exam (60%). In addition, at the end of the course, a final exam will be carried out where the global knowledge acquired by the students will be evaluated. A minimum mark will be required in the written assessment.

Final exam Percentage: 60
Continuous evaluation Percentage: 40

BASIC BIBLIOGRAPHY

- BARRADO, A. LÁZARO Problemas de Electrónica de Potencia, Pearson Prentice Hall, 2007

- D.W. HART Power Electronics, McGraw-Hill Education, 2010

ADDITIONAL BIBLIOGRAPHY

- A. YAZDANI, R. IRAVANI Voltage-Sourced Converters in Power Systems, IEEE PRESS ¿ Wiley , 2010

- D.G. HOLMES, T.A. LIPO Pulse Width Modulation for Power Converters, IEEE PRESS ¿ Wiley Interscience, 2003

- M.H. RASHID Electrónica de Potencia: Circuitos, Dispositivos y Aplicaciones, Pearson Prentice-Hall, 2004

- N. MOHAN, T.M. UNDELAND, W.P. ROBBINS Power electronics, converters, applications and design, John Wiley & Sons, 2003

- R. TEODORESCU, M. LISERRE, P. RODRIGUEZ Grid Converters for Photovoltaic and Wind Power Systems, IEEE Press - Wiley, 2011

- R.W. ERICKSON, D. MAKSIMOVIC Fundamentals of Power Electronics, Kluwer Academic Publishers, 2001