Course guides
820124 - EPEE - Power Electronics

Last modified: 11/04/2022

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

Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2021 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: ROBERT PIQUÉ LOPEZ

Others: FRANCISCO BOGONEZ FRANCO
FRANCISCO CASELLAS BENEYTO
JORDI CLOS GARRIDO
ZACHARIE JEHL
NICOLAS MURGUIZUR BUSTOS
ROBERT PIQUE LOPEZ
MARCEL PLACIDI

PRIOR SKILLS

Those of the obligatory subjects of preceding levels (semesters).

REQUIREMENTS

SISTEMES ELECTRÒNICS - Prerequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Understand the applications of power electronics.

Transversal:
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
4. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
5. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

TEACHING METHODOLOGY

The course uses in the classroom the expositive methodology by 60%, individual work by 10% and peer to peer work (twos students) by 30% under PBL (Problem-Based Learning) approach.

Outside the classroom individual work is weighted by 60%, while the small group work, for the deliverables of theory and practice, occupies 40%.

LEARNING OBJECTIVES OF THE SUBJECT

Upon successful completion of this course, students will be able to:

- Describe the essential contents of the syllabus for the course and its justification (Knowledge).
- Describe the scope across the course in Engineering (Understanding).
- Describe the state of the art, trends and limitations of the components used in power electronics (Knowledge-Understanding).
- Describe justifiably the various types of switches and the switching process (Comprehension).
- Describe the main structures of static conversion and its functional principle (Understanding).
- Determine analytically the response of the basic steady static converters (Application-Analysis).
- Synthesizing a basic structure of conversion from the requirements of the sources to be linked (Application-Synthesis).
- Describe the main methods of closed loop control for static converters (Understanding-Application).
- Properly use the PSIM simulator as aid in the analysis of static converters (Understanding-Application).
- Evaluate the increase of knowledge that has brought up the subject (Evaluation).

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	30.00
Self study	90,0	60.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

1. Introduction to Power Electronics.

Description:
1.1. Some definitions. 1.2. Classification of static converters. 1.3. Static converters in steady-state. 1.4. Components for power electronics: current status and trends.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

2. Switches and Switching.

Description:
2.1. Dipoles. Current-voltage characterization. Static characteristic. Power dissipation. Sources. Resistors. 2.2. Switches. Static characteristics. Switching. Dynamic (or control) characteristic. Market switches and synthesis switches. State transition diagrams. 2.3. Switching process. Soft switching. Approaches to the soft switching. 2.4. Synthesis of elementary converters.

Related activities:
Practice 1: Introduction to Power Electronics Laboratory.

Full-or-part-time: 15h
Theory classes: 4h 30m
Laboratory classes: 2h
Self study : 8h 30m

3. Components and protections; practical considerations.

Description:
3.1 Diodes. 3.2. Transistors. 3.3. Thyristors. 3.4. Other switches. 3.5. Some considerations about the association of switches. 3.6. Electrical protections. 3.7. Termal protections.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

4. DC to DC Converters.

Description:
4.1. Basic principle of DC-DC converters. 4.2. Rules for sources interconnection. 4.3. DC-DC converters structures. 4.4. Chopper analysis. 4.5. One-quadrant DC-DC converters. 4.6. Two and four quadrants operation. 4.7. Isolated DC-DC converters. 4.8. PWM control of DC-DC converters. 4.9. Dynamic modelization: state-space averaging.

Related activities:
Practices 2 and 3: DC-DC converters.

Full-or-part-time: 35h
Theory classes: 9h 30m
Laboratory classes: 4h
Self study : 21h 30m

5. DC to AC Converters.

Description:
5.1. DC-AC conversion concept: time and frequency. 5.2. Inverter structures. 5.3. One-phase inverters. 5.4. Inverters analysis. 5.5. Harmonic control. Harmonic elimination techniques. 5.6. SSPWM modulation. 5.7. 3-Phase inverters. 5.8. Introduction to PV systems with hybrid inverters.

Related activities:
Practice 4: DC-AC converters.
Week number 8 (9) of the course: Completing the written test ET1 (chapters 1 to 5).

Full-or-part-time: 20h
Theory classes: 6h
Laboratory classes: 2h
Self study : 12h

6. AC to DC Converter.

Description:
6.1. Rectifier concept. 6.2. Basic operation under different load conditions. 6.3. Commutation groups. 6.4. Uncontrolled, controlled and semi-controlled rectifiers. 6.5. P-type rectifiers 6.6. PD-type rectifiers. 6.7. S-type rectifiers. 6.8. Voltage drops. 6.9. Rectifiers association. 6.10. Comparative characteristics.

Related activities:
Practice 5: AC-DC converters.

Full-or-part-time: 30h
Theory classes: 9h
Laboratory classes: 2h
Self study : 19h

7. AC to AC Converters.

Description:
7.1. AC to AC conversion concept. 7.2. One-phase regulator with phase control. 7.3. Three-phase regulator with phase control. 7.4. Regulator with integral cycle control. 7.5. Cycloconverters. 7.6. Matrix converters.

Related activities:
Practice 6: AC-AC converters - Individual assessment of lab's work.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 2h
Self study : 5h

8. Introduction to closed-loop control of static converters.

Description:
8.1. Concepts of modeling and simulation. 8.2. General structure and functional blocks of a conventional control scheme of static converters in closed loop. 8.3. Closed loop control of PWM converters. Control electronics and driving. Voltage-mode control. Cascade control. Current-mode control. Reference-wave control. 8.4. Closed loop control of the converter with phase control. Control electronics and driving. Voltage-mode control. 8.5. An introduction to Energetic Macroscopic Representation (EMR) and Inversion-Based Control (IBC).

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

9. Applications and Trends in Power Electronics.

Description:
9.1. Classical, current and advanced views of Power Electronics. 9.2. Classifications of the fields and applications of Power Electronics. 9.3. Emerging fields 9.4. Performances. 9.5. Domestic applications. Electric transport and mobility. Industrial and utility applications. Applications in the field of energy. Advanced applications: Energy harvesting, Integration, Electroactive materials, Future components. 9.6. Energy and environmental Sustainability. The electric power chain. The European transitions H2040. Smart Microgrids: Definition; Functional and structural characteristics; Energy management systems; State of the art and trends.

Related activities:
Week number 12 (3) of the course: Completing the written test ET2 (chapters 6 to 9).

Week 14 (15): Preparation and public presentations of theory delivery made in collaborative group.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

GRADING SYSTEM

Course evaluation is based on continuous assessment tests, PAC. In addition to the traditional summative assessments, formative assessments are also used as a feedback.

The set of PACS consists of 2 written exercises (ET) on specific knowledge, 6 mandatory practices (lab sessions) and one deliverable (LT) oriented to PBL (Problem-Based Learning). From each practice, the laboratory work and its written report are evaluated, being able to contemplate other aspects such as the preparation of the practice or follow-up tests. The assessment tests, except the ET's, including generic and specific goals.

The weights assigned to each PAC are as follows:

ET1: 25%; ET2: 25%; LT: 20%; Practices: 30%.

With the above tests, the qualification of the subject, Ncurs, is obtained.

There isn't a last test in the classical sense of a final exam.

In Power Electronics there are a number of assessment blocks that, in accordance with the specific academic regulations of the EEBE, is considered marked continuous assessment methodology and, therefore, is exempt from reassesment.

If Ncurs> = 5.0 is achieved suitable for the subject, obtaining a rating given by NOTA = Ncurs. Otherwise should return to complete the course in its entirety. For more details, see the "Power Electronics student guide" available in Atenea.

EXAMINATION RULES.

Irregular actions that can lead to a significant variation of the qualification of one or more students constitute a fraudulent accomplishment of an evaluation act. This action entails the descriptive rating of suspense and numerical of 0 of the assessment act and of the subject, without prejudice to the disciplinary process that can be derived as a consequence of the acts carried out. (Academic Regulations for Bachelor and Master's Degrees at the UPC. Section 3.1.2.)

In accordance with section 3.1.3 of the Academic Regulations for Bachelor and Master's Degrees at the UPC, the completion of the laboratory practices and the delivery of theory is compulsory in order to qualify for the subject.

See details in the "Guia de l'Estudiant d'Electrònica de Potencia" at Atenea virtual campus.

Remember that by regulations it's mandatory to have a valid ID (identity card, Passport or estudent card).

BIBLIOGRAPHY

Basic:
- Piqué, Robert. Exercicis d'Electrònica de Potència per a consolidació de conceptes. Barcelona: UPC, 2019.
- Ballester Portillo, Eduard; Piqué, Robert. Electrónica de Potencia. Principios Fundamentales y Estructuras Básicas. Barcelona: Marcombo, 2011. ISBN 9788426716699.
- Piqué, Robert. Exercicis d'Electrònica de Potència per a preparació dels ETs. 2a ed. Barcelona: UPC, 2019.
- Piqué, Robert; Román, Manuel; Gayà, Pedro; Ballester, Eduard. Manual de pràctiques d'Electrònica de Potència. 8ena ed. Barcelona: UPC, 2018.

Complementary:
- Mohan, Ned; Undeland, Tore M.; Robbins, William P. Power electronics : converters, applications, and design. New York [etc.]: John Wiley & Sons, cop. 2003. ISBN 0471226939.
- Erickson, Robert W.; Maksimovic, Dragan. Fundamentals of power electronics [on line]. 2nd ed. Dordrecht: Kluwer Academic Publishers, cop. 2001 [Consultation: 04/05/2020]. Available on: https://link.springer.com/book/10.1007/b100747. ISBN 0792372700.
- Krein, Philip T. Elements of power electronics. New York: Oxford University Press, 1998. ISBN 0195117018.

RESOURCES

Other resources:

All documentation and course resources (slides, guided exercises, templates, assessment rubrics, feedbacks, surveys, Programme Groups, etc.) is available on the digital campus Athena.