820223 - EPEIA - Power Electronics

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff
Coordinator: ROBERT PIQUÉ LOPEZ
Others:
Primer quadrimestre:
MAZIAR AHMADI ZEIDABADI - T14
FRANCISCO JOSÉ CASELLAS BENYEYO - T11, T12, T13, T14
OLIVER MILLÁN BLASCO - T11, T12, T13

Segon quadrimestre:
FRANCISCO BOGONEZ FRANCO - M13, M14
PEDRO FRANCISCO GAYA SUÑER - M11, M12
XAVIER MARIMON SERRA - M15
ROBERT PIQUÉ LOPEZ - M11, M12, M13, M14, M15

Opening hours
Timetable: Check in each case the particular information at Atenea digital campus.

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

Requirements
SISTEMES ELECTRÒNICS - Prerequisite

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
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- 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).

5. EFFECTIVE USE OF INFORMATION 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).
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Study load

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 150h</th>
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</thead>
<tbody>
<tr>
<td>Hours large group:</td>
<td>45h</td>
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<tr>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td>Hours small group:</td>
<td>15h</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>90h</td>
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</tbody>
</table>

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

### 1. Introduction to Power Electronics.

**Learning time:** 10h
- Theory classes: 3h
- Self study: 7h

**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.

### 2. Switches and Switching.

**Learning time:** 15h
- Theory classes: 4h 30m
- Laboratory classes: 2h
- Self study: 8h 30m

**Description:**
- 2.4. Synthesis of elementary converters.

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

### 3. Components and protections; practical considerations.

**Learning time:** 10h
- Theory classes: 3h
- Self study: 7h

**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. Thermal protections.
### 4. DC to DC Converters.

<table>
<thead>
<tr>
<th>Description:</th>
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</thead>
<tbody>
<tr>
<td>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.</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>Practices 2 and 3: DC-DC converters.</td>
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<table>
<thead>
<tr>
<th>Learning time:</th>
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<tbody>
<tr>
<td>35h</td>
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<table>
<thead>
<tr>
<th>Theory classes:</th>
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<tbody>
<tr>
<td>9h 30m</td>
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<table>
<thead>
<tr>
<th>Laboratory classes:</th>
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<tbody>
<tr>
<td>4h</td>
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<table>
<thead>
<tr>
<th>Self study :</th>
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<tbody>
<tr>
<td>21h 30m</td>
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### 5. DC to AC Converters.

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<th>Description:</th>
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<tbody>
<tr>
<td>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.</td>
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<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>Practice 4: DC-AC converters.</td>
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<tr>
<td>Week number 8 (9) of the course: Completing the written test ET1 (chapters 1 to 5).</td>
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<table>
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<tbody>
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<td>6h</td>
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<table>
<thead>
<tr>
<th>Laboratory classes:</th>
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<tbody>
<tr>
<td>2h</td>
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<table>
<thead>
<tr>
<th>Self study :</th>
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<tbody>
<tr>
<td>12h</td>
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### 6. AC to DC Converters.

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>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.</td>
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<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>Practice 5: AC-DC converters.</td>
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<table>
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<tr>
<th>Learning time:</th>
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<tbody>
<tr>
<td>30h</td>
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<table>
<thead>
<tr>
<th>Theory classes:</th>
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<tbody>
<tr>
<td>9h</td>
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<table>
<thead>
<tr>
<th>Laboratory classes:</th>
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<tbody>
<tr>
<td>2h</td>
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<table>
<thead>
<tr>
<th>Self study :</th>
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<tbody>
<tr>
<td>19h</td>
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</table>
### 7. AC to AC Converters.

**Learning time:** 10h  
- Theory classes: 3h  
- Laboratory classes: 2h  
- Self study: 5h

**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.

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

**Learning time:** 10h  
- Theory classes: 3h  
- Self study: 7h

**Description:**  
8.2. General structure and functional blocks of a conventional control scheme of static converters in closed loop.  
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).


**Learning time:** 10h  
- Theory classes: 3h  
- Self study: 7h

**Description:**  
9.2. Classifications of the fields and applications of Power Electronics.  
9.3. Emerging fields.  
9.4. Performances.  
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 (13) of the course: Completing the written test ET2 (chapters 6 to 9).  
Week number 14 (15): Preparation and public presentation of theory delivery made in collaborative group.
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### Qualification 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 or exam 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 reassessment.

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.

### Regulations for carrying out activities

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).
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Bibliography

Basic:


Complementary:


Others resources:

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