820124 - EPEE - Power Electronics

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering
Academic year: 2018
Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6

Teaching languages: Catalan

Teaching staff
Coordinator: PIQUÉ LÓPEZ, ROBERT
Others: FRANCISCO JOSÉ CASELLAS BENEYTO - PEDRO GAYA SUÑER - ROBERT PIQUÉ LOPEZ - XAVIER ROSET JUAN

Opening hours
Timetable: Check in each case the particular information

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

Requirements
Having completed the course ELECTRONIC SYSTEMS (STI)

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 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%.
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

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group</th>
<th>Hours medium group</th>
<th>Hours small group</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time: 150h</td>
<td>45h</td>
<td>0h</td>
<td>15h</td>
<td>0h</td>
<td>90h</td>
</tr>
<tr>
<td>30.00%</td>
<td>0.00%</td>
<td>10.00%</td>
<td>0.00%</td>
<td>60.00%</td>
<td></td>
</tr>
</tbody>
</table>
### 1. Introduction to Power Electronics

**Description:**

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>3h</td>
</tr>
<tr>
<td>Self study:</td>
<td>7h</td>
</tr>
</tbody>
</table>

### 2. Switches and Switching

**Description:**

**Related activities:**
Practice 1: Introduction to Power Electronics Laboratory. Week number 4 of the course: Completing the written test ET1 (chapters 1 and 2).

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>15h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>4h 30m</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Self study:</td>
<td>8h 30m</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>10h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>3h</td>
</tr>
<tr>
<td>Self study:</td>
<td>7h</td>
</tr>
</tbody>
</table>

**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.

**Learning time:** 35h  
Theory classes: 9h 30m  
Laboratory classes: 4h  
Self study: 21h 30m

**Description:**
- 4.1 Basic principle of DC-DC converters.
- 4.2 Rules for sources interconnection.
- 4.3 Basic one-quadrant DC-DC converters.
- 4.4 Buck converter.
- 4.5 Boost converter.
- 4.6 Buck-Boost converter.
- 4.7 Two and four quadrants operation.
- 4.8 Isolated DC-DC converters.
- 4.9 PWM control of DC-DC converters.

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

### 5. DC to AC Converters.

**Learning time:** 20h  
Theory classes: 6h  
Laboratory classes: 2h  
Self study: 12h

**Description:**
- 5.1 DC-AC conversion concept: time and frequency.
- 5.2 Inverter structures.
- 5.3 Half-bridge and full-bridge inverters.
- 5.4 Basic commutation techniques: square and quasi-square waves.
- 5.5 PWM techniques. Bipolar and unipolar SSPWM.
- 5.6 Three-phase inverters. Unmodulated control and PWM control.
- 5.7 Harmonic control. Harmonic elimination techniques.

**Related activities:**
Practice 4: DC-AC converters.
Week number 8 of the course: Completing the written test ET2 (chapters 3 and 4).

### 6. AC to DC Converter.

**Learning time:** 30h  
Theory classes: 9h  
Laboratory classes: 2h  
Self study: 19h

**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.
### 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.
- Week number 12 of the course: Completing the written test ET3 (chapters 5 and 6).

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

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

**Description:**

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


**Description:**
9.1 Energy and sustainability. The electrical energy chain. Overview and main fields of application. 9.2 Conversion to renewable energy. 9.3 High DC-voltage electricity transmission. 9.4 Traction. 9.5 Static reactive power compensation. Harmonic control. 9.6 Power systems. 9.7 Electric drives. 9.8 Uninterruptible power systems. 9.9 Domestic applications. 9.10 Smart Grid. 9.11 Other applications.

**Related activities:**
- Week number 14 of the course: Completing the written test ET4 (chapters 7, 8 and 9).
- Week number 15: Preparation and public presentations of theory delivery made in collaborative group.

**Learning time:**
- Theory classes: 3h
- Self study: 7h
Curse evaluation is based on continuous assessment tests, PAC, and practices. In addition to the traditional summative assessments, formative assessments are also used as a feedback.

The set of PACS consists of 3 written exercises (ET) on specific knowledge and one deliverable oriented to PBL (Problem-Based Learning). Evaluates each practice preparation, laboratory work and report writing. The assessment tests, except the ET’s, including generic and specific goals. The weights assigned to each part are as follows:

PACS: 70%
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 four assessment blocks, three of theory and problems (PAC1, PAC2 and PAC3) with 23.3% weight each PAC, and practices, weight 30%. According to the specific academic regulations of the EEBE, sections 2.2.b and 2.2.c, 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

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

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

Bibliography

Basic:


Ballester, Eduard; Piqué, Robert; Román, Manuel. Pràctiques d'electrònica de potència. 3a ed. Barcelona: UPC, 2011.

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.