Learning objectives of the subject:

The objective of the course is to introduce several advanced control techniques and their application to the power processing control involved in renewable energy systems.

Learning results of the subject:

- Ability to describe the suitable tools leading to the dynamical models of the power processors involved in the photovoltaic and wind energy conversions to electrical power.
- Ability to analyze the control problems related with photovoltaic and wind energy conversions in different power processing scenarios (stand-alone systems, grid connected systems etc.)
- Ability to apply several nonlinear control techniques (nonlinear feedback for global linearization, energy balance techniques (passivity), variable-structure systems based techniques (sliding mode control) and fuzzy control) to solve the control problems involved in the photovoltaic and wind energy conversion systems.
- Ability to compare the features of the advanced controllers with those resulting from classical ones. This comparison will lead to establish several criteria to the selection of the most suitable controllers.
- Ability to develop techniques for the design, analysis and evaluation of electronic systems in applications such as
automation, aerospace, energy distribution and generation, consumer electronics, biomedicine, etc.
- Ability to analyze, design and evaluate electronic systems for power control and energy conversion.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group:</th>
<th>39h</th>
<th>31.20%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
</tr>
</tbody>
</table>
## Content

### 1. Power conversion in renewable energy systems. Control requirements.

**Description:**
- Renewable energy sources.
- Power conversion involved in renewable energy systems

**Learning time:** 9h  
  - Theory classes: 3h  
  - Self study: 6h

### 2. Nonlinear control techniques in power electronics

**Description:**
- Dynamical behaviour of switched power conversion systems. Modelling and control problems.
- State-space dynamical models. Definitions: state variables, state-space, equilibrium points. Application to basic switched converters.
- Lyapunov stability criteria: local and global stability.
- Variable-structure systems control. ("Sliding-Mode Control")
- Fuzzy control for switched power converters.
- Passivity-based Control

**Learning time:** 67h  
  - Theory classes: 21h  
  - Self study: 46h

### 3. Advanced controllers design for photovoltaic conversion systems

**Description:**
- Power conversion scenarios: power conversion elements involved in stand-alone and grid-connected PV systems.
- Power conversion chain modelling in PV systems.
- Control goals in PV systems.
- Maximum Power Point Tracking (MPPT) of PV arrays.
- Quality factors in grid-connected PV systems. Inverters and modular systems.
- Voltage regulators, batteries, and battery chargers.
- Design of controllers:
  - Control design based on linear techniques.
  - Control design based on advanced nonlinear techniques.

**Learning time:** 49h  
  - Theory classes: 15h  
  - Self study: 34h
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Planning of activities

EXERCISES

Description:
- Exercises on linear control design of a battery charger from PV panels.
- Exercises on nonlinear control design of a battery charger from PV panels.
- Power management of PV grid-connected system with AC and DC loads.

ORAL PRESENTATION

Description:
Presentation of a work group

Qualification system

Individual assessments: from 20% to 40%
Group assessments: from 60% to 80%
Bibliography

Basic:


Complementary:


Others resources:

Course slides. Technical papers provided.