UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
320129 - ACSEP - Applications and Control of Power Electronic Systems

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Antoni Arias

Others:

PRIOR SKILLS

Students might have passed the courses of Control Engineering (Q6) and Power Electronics (Q5, Q6).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
3. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
4. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

TEACHING METHODOLOGY

In the theory sessions, the teacher will introduce the theoretical basis.
The exposition of the concepts and their implementation should be made clearly and concisely
all illustrating examples to facilitate understanding. Students will work and adapt the examples
theory for application sessions in order to do lab sessions.
In the laboratory, students must achieve the concepts covered in the theory sessions and implementation.
Students will use Matlab-Simulink software as a laboratory tool.

LEARNING OBJECTIVES OF THE SUBJECT

The student should be able to understand, analyze and design control for applications where
actuators are power electronic converters.
The course is marked as a challenge to link knowledge and subjects of Engineering Control and Industrial Electronics and Power.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

TOPIC 1: Presentation of the course

Description:
·Presentation of course content and its program (Theory, Application, and Lab Activities Directed).

· Assessment Regulations.

·Basic and complementary bibliography .Tool and computer-aided design (Matlab-Simulink).

· Applications: Renewable Energy, Electric Vehicle, Mechatronics, Power Quality.

· State of the art.

· Matlab / Simulink as a basic tool for modeling and simulation for the various applications

Full-or-part-time: 1h
Theory classes: 1h

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TOPIC 2: Tools for modelling power electronics converters

Description:
·Models converters.
Switching.
Averages of large signal and small signal.

·Three phase transformations.
Clarke (_-_).
Park (d-q).
·Model three-phase inverter connected to the network
Coordinates a-b-c and d-q.
Small signal

· Modeling of permanent magnet synchronous machine.
Characteristics.
Electrical part in coordinates (a, b, c), (_-_) and (dq).
Mechanical part

Related activities:
· Simulation model of a permanent magnet synchronous machine.

· Simulation model of a three-phase inverter connected to the grid

Full-or-part-time: 13h
Theory classes: 6h
Practical classes: 3h
Laboratory classes: 4h

TOPIC 3: Control applications with electric machines

Description:
· Vector Control (FOC: Field Oriented Control) in four quadrants. (2hT has +1)
Analogy to the DC motor.
Tuning controllers running through the root locus.
PI pre-filter or IP.
Matlab Sisotool and Control toolbox
Feedforward terms
Anti wind up.

· DTC: Direct Torque Control into four quadrants.
Control of hysteresis comparators.

· External velocity and position loops.
Tuning controllers using root locus
Feedforward control for changes in load torque.
Matlab Sisotool and Control toolbox.

· Introduction to DSP implementation
Step controller in continuous time to discrete time. Sampling periods for current loops
and speed or position.
Programming the controller.
DSP / FPGA Architectures.

· Applications in Renewable Energy, Electric Vehicle, Industrial Drives and Mechatronics.

· State of the art industry.
Commercial products based on FOC (Emerson, Eurotherm, etc...) and DTC (ABB)

· State of the art research.
Control in state space.
The challenge of Sensorless Control.

· Estimators, observers and tracking techniques.
Research laboratories. Testing.

Related activities:
· Model simulation of vector control of permanent magnet motor with external loop speed and / or position
In continuous time.
Discrete-time and three-phase inverter.
With speed and position estimator (Sensorless).

· Simulation model of direct torque control of a permanent magnet motor with external speed loop and / or position.

Full-or-part-time: 24h
Theory classes: 11h
Practical classes: 6h
Laboratory classes: 7h

TOPIC 4: Applications of investors connected to the network

Description:
· Duality FIRE - VOC DTC - DPC

· VOC-Voltage Oriented Control
Internal loop active and reactive currents. Power Factor Control. Synchronization with the network.
External loop voltage.

· DPC Direct Power Control
Control of hysteresis comparators.

· Applications in renewable energy, electric vehicles, energy storage, HVDC transmission

· State of the art industry
Commercial products.

· State of the art research
Multilevel converters.
Feedforward control, predictive, multivariate, etc..
Research laboratories.

Related activities:
·Model-oriented simulation of a control voltage (VOC).
· Simulation model of a direct power control (DPC).

Full-or-part-time: 16h
Theory classes: 8h
Practical classes: 4h
Laboratory classes: 4h

TOPIC 5: Renewable Energy applications and others

Description:
· Generation of wind power.
Fixed speed
Variable speed. Operation modes.
Wind generator system based on permanent magnets.
Back to back connection. Crowbar by the DC bus.

· Generating solar energy.
Modeling of photovoltaic panels.
Maximum power tracking techniques.
Photovoltaic systems autonomous and connected to the grid.

· Other energies: navy, etc. ...

· Electric vehicles and other drives.

Related activities:
·Adaptation of previous models to a particular application (chosen by students).

Full-or-part-time: 15h
Theory classes: 6h
Practical classes: 3h
Guided activities: 6h

GRADING SYSTEM

·1st Exam: 25%
· 2nd Exam: 25%
· Lab: 25%
·AD: 25%

BIBLIOGRAPHY

Basic:
- Kazmierkowski, Mariam P.; Krishnan, R.; Blaabjerg, Frede. Control in power electronics: selected problems [on line]. Amsterdam: Academic Press, 2002 [Consultation: 09/05/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780124027725/control-in-power-electronics. ISBN 0124027725.
- Dorf, R. C.; Bishop, R. H. Modern control systems. 12th ed. Boston: Pearson, 2011. ISBN 9780131383104.

Complementary:
- Ogata, K. Modern control engineering. 5th ed. Boston: Pearson, 2010. ISBN 9780137133376.
- Vas, P. Sensorless vector and direct torque control. Oxford: Oxford University Press, 1998. ISBN 0198564651.
- Blaabjerg, F.; Chen, Z. Power electronics for modern wind turbines. [S.l.]: Morgan & Claypool, 2006. ISBN 1598290320.