Course guide
230676 - PCRES - Power Control for Renewable Energy Systems

Last modified: 10/11/2022

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

Degree: MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2022 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Group work (distance)
- Individual work (distance)
- Exercises
- Oral presentations
- Other activities

LEARNING OBJECTIVES OF THE SUBJECT

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

Type	Hours	Percentage
Hours large group	39,0	31.20
Self study	86,0	68.80

Total learning time: 125 h

CONTENTS

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

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

Full-or-part-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

Full-or-part-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.

Full-or-part-time: 49h
Theory classes: 15h
Self study : 34h

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

GRADING SYSTEM

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

BIBLIOGRAPHY

Basic:
- Fundamentos, dimensionado y aplicaciones de la energía solar fotovoltaica. [ed. act.]. Madrid: Ministerio de Ciencia y Tecnologia : Ciemat, 2006. ISBN 8478345140.

Complementary:
- Utkin, V.I.; Guldner, J.; Shi, J. Sliding mode control in electro-mechanical systems. 2nd ed. Boca Raton, FL: CRC Press, 2009. ISBN 9781420065602.
- Khalil, H.K. Nonlinear systems. 3rd ed. Upper Saddle River, NJ: Prentice-Hall, 2014. ISBN 9781292039213.
- Sabanovic, A.; Fridman, L.M.; Spurgeon, S. (eds.). Variable structure systems: from principles to implementation. London: IEE Control Series, 2004. ISBN 0-86341-350-1.
- Driankov, D.; Hellendoorn, H.; Reinfrank, M. An introduction to fuzzy control. 2nd ed. Berlin: Springer Verlag, 1996. ISBN 3540606912.
- Wang, L.X. A Course in fuzzy systems and control. Upper Saddle River, NJ: Prentice Hall, 1997. ISBN 0135408822.

- Passino, K. M.; Yurkovitch, S. Fuzzy control. Menlo Park: Addison Wesley, 1998. ISBN 020118074X.
- Ortega, R.; Loria, A.; Nicklasson, P. J.; Sira-Ramirez, H. Passivity-based control of Euler-Lagrange systems: mechanical, electrical and electromechanical applications. London: Springer-Verlag, 1998. ISBN 1852330163.
- van derSchaft, A.J. L2-gain and passivity techniques in nonlinear control [on line]. 3rd ed. Cham: Springer, 2017 [Consultation: 13/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-319-49992-5. ISBN 9783319499925.
- Strong, S.J.; Scheller, W.G. The solar electric house: energy for the environmentally-responsive, energy-independent home. Still River, Massachusetts: Sustainability Press, 1993. ISBN 0-9637383-2-1.
- Lorenzo, E. [et al.]. Solar electricity : engineering of photovoltaic systems. Madrid: Polytechnic University of Madrid, Institute of Solar Energy, 1994. ISBN 84-86505-55-0.
- McEvoy, A.; Markvart, T.; Castañer, L. (eds.). Practical handbook of photovoltaics: fundamentals and applications. 2nd ed. Amsterdam: Academic Press, 2011. ISBN 9780123859341.
- Erickson, R.W.; Maksimovic, D. Fundamentals of power electronics [on line]. 2nd ed. Dordrecht: Kluwer Academic Publishers, 2001 [Consultation: 11/02/2015]. Available on: http://link.springer.com/book/10.1007/b100747/page/1. ISBN 0792372700.

RESOURCES

Other resources:
Course slides. Technical papers provided.