

Course guide 340671 - ESER - Electronics in Renewable Energy Systems

Last modified: 03/04/2024

Unit in charge: Teaching unit:	Vilanova i la Geltrú School of Engineering 710 - EEL - Department of Electronic Engineering.		
Degree:	 BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject). BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Optional subject). BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject). BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject). 		
Academic year: 2024	ECTS Credits: 6.0 Languages: Catalan, Spanish		
LECTURER			

Coordinating lecturer:	ANTONIO MIGUEL LOPEZ MARTINEZ
Others:	ANTONIO MIGUEL LOPEZ MARTINEZ

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. CE16. Basic knowledge and application of environmental technologies and sustainability.

2. CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.

3. CE20. Knowledge of machine controlling and electrical operations and its applications.

4. CE21. Ability to design and calculate electrical installations of low or middle tension.

5. CE24. Knowledge of electrical power systems and its applications.

6. CE7. Knowledge of applied thermodynamics and heat transfer. Basic principles and its application in solving engineering problems.

7. CE8. Knowledge of basic principals of fluid mechanic and its application to resolve problems in engineering area. Calculus of channels, canals and fluids.

Transversal:

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.



TEACHING METHODOLOGY

Teaching-learning activates - participative and masterful with support multimedia with a continuous tutor action.

Objectives of the used methodology

- To promote the knowledge for comprehension.
- To create the necessity to continue learning.
- To create an atmosphere of personal and collaborador work and between the students.

- That the student assumes the responsibility and protagonism of the learning.

LEARNING OBJECTIVES OF THE SUBJECT

1. Know the energy resources, current panorama and energy trend.

2. Know how to size energy systems (photovoltaic, thermal, wind) according to the energy requirements of a given application.

Analysis and synthesis of analog and digital electrical and electronic circuits for the control of systems related to renewable energy.
 Knowledge of minimum consumption systems (low power, harvesting, IoT).

5. Know and to use hardware and software for the simulation and optimization of photovoltaic-thermal and wind systems. (Matlab, Simulink basically)

6. Analysis and synthesis of projects for the development of renewable energy systems, attending to the control electronics and actuators.

STUDY LOAD

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

Total learning time: 150 h



CONTENTS

Unit 1.- Global aspects of energy and associated electronic systems.

Description:

- 1. Historical overview of energy.
- 2. Limitation of conventional resources and their problems.
- 4. Renewable energy resources. Harvesting and Low power.
- 5. Introduction to the control and power system. Related electronic technology.

Specific objectives:

Contribute knowledge on the historical and current panorama of the different energy resources.

Know the real limitations of traditional energy sources in relation to energy considered renewable.

Introduce the student to the basic operation of the most important renewable energies from the point of view of technology and electronic systems

Related competencies :

. CE16. Basic knowledge and application of environmental technologies and sustainability.

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02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.

Full-or-part-time: 15h Theory classes: 4h 30m Laboratory classes: 1h 30m Guided activities: 1h Self study : 8h



Unit 2.- Photovoltaic Solar Energy Processing.

Description:

- 1. Characteristics of solar radiation.
- 2. Photovoltaic conversion: Theory of semiconductors oriented to photovoltaic production.
- 3. Definition of the photovoltaic system.
- 4. Components of the photovoltaic installation: The photovoltaic cell: analysis and design.
- 5. The photovoltaic panel. Panel Association.
- 6. Essential elements in the photovoltaic system.
- 7. Maximum Power Point Tracking Algorithms (MPPT).
- 8. Design and control of DC / DC converters.
- 9. Battery chargers.
- 10. Topologies of systems connected to the network.
- 11. Design and control of DC / DC and DC / AC converters.
- 12. Design of the photovoltaic installation by means of the energy balance and optimal use of the solar collection.
- 13. Electrical protection systems.
- 14. Processing of energy for sale to the grid.
- 15. Introduction to the concept of Smart Grid

Specific objectives:

- \cdot Know different mathematical models of the photovoltaic cell.
- · Know the concept of power source and photovoltaic system and associated electronic technology.
- \cdot Optimization of the energy flow in the photovoltaic system using electronic systems.
- · Know how to design DC-DC converters. i DC-AC.
- · Know the different topologies of power processing in grid current injection.

Related activities:

To know how to model the cell and the photovoltaic panel mathematically.

To know different algorithms of maximum power point tracking (MPPT).

To know how to design the AD-AD and AD-AC convertors in connection with the current injection grid.

To know the development of power equipment in eolic-electric systems.

Related competencies :

. CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.

. CE20. Knowledge of machine controlling and electrical operations and its applications.

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Full-or-part-time: 37h

Theory classes: 12h Practical classes: 4h Guided activities: 1h Self study : 20h



Unit 3.- Thermoelectric Power Processing

Description:

- 1.- Introduction to thermoelectricity. Principles of operation.
- 2.- Equivalent electrical model. Peltier mode and Seebeck mode.
- 3.- Characteristic curves of power, voltage and performance.
- 4.- Electronic control systems for thermoelectric structures.
- 5.- Design of a cold cabinet.
- 6.- Behavior in Seebeck mode as an electric power generator.
- 7.- Design examples with thermoelectric structure.
- 8.- Harvesting with thermoelectric systems. Switched capacity sources.

Specific objectives:

- \cdot Know the basic characteristics of thermoelectric energy.
- · Make use of the mathematical model that describes the operation of thermoelectric cells and know their main applications.
- \cdot Know how to design a control system on a thermoelectric structure.
- · Have knowledge of the interaction between thermoelectric technology and photovoltaic technology.
- · Carry out practical experiences in this field.

Related competencies :

. CE7. Knowledge of applied thermodynamics and heat transfer. Basic principles and its application in solving engineering problems.

. CE8. Knowledge of basic principals of fluid mechanic and its application to resolve problems in engineering area. Calculus of channels, canals and fluids.

. CE24. Knowledge of electrical power systems and its applications.

. CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.

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Full-or-part-time: 21h 30m

Theory classes: 10h Practical classes: 2h 30m Guided activities: 1h Self study : 8h



Unit 4.- Fuel Cells. Energy Processing.

Description:

- 1.- Introduction to H2-based fuel cells (FC).
- 2.- Basic structure of the FC H2 and operation.
- 3.- Performance of FC H2.
- 4- Advantages of using H2 FCs.
- 5.- Faraday Efficiency and Energy Efficiency.
- 6.- Electronic control systems on the H2 FC.

Specific objectives:

 \cdot Know the structure of a solid electrolyte-based hydrogen cell.

- . Know concepts about the performance of an H2 FC.
- . Control systems and associated electronic technology.

Related competencies :

. CE7. Knowledge of applied thermodynamics and heat transfer. Basic principles and its application in solving engineering problems.

. CE8. Knowledge of basic principals of fluid mechanic and its application to resolve problems in engineering area. Calculus of channels, canals and fluids.

. CE24. Knowledge of electrical power systems and its applications.

. CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.

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Full-or-part-time: 21h Theory classes: 9h 30m Practical classes: 2h 30m Guided activities: 1h Self study : 8h



Unit 5.- Wind Energy Processing.

Description:

- 1.- Introduction to wind energy.
- 2.- Wind power. Betz's law. Wind energy measurement. Speed distribution. Performance.
- 3.- Wind turbines. Types and parts of a wind turbine. Aerodynamic operation.
- 4.- Mechanical and electronic power control.
- 5.- Network connection. Electronic power systems. Associated electronic technology.

Specific objectives:

- . Know the principles of wind energy
- . Know the measurement of the parameters associated with wind energy.
- Know the erodynamic structure of a wind turbine.
- Know the main electronic control structures used in a wind turbine. Power grid distribution.

Related competencies :

- . CE21. Ability to design and calculate electrical installations of low or middle tension.
- . CE8. Knowledge of basic principals of fluid mechanic and its application to resolve problems in engineering area. Calculus of channels, canals and fluids.
- . CE24. Knowledge of electrical power systems and its applications.
- . CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.
- 05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
- 07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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Full-or-part-time: 24h Theory classes: 6h Practical classes: 3h Guided activities: 1h Self study : 14h



Unit 6.- IoT (Internet of Things) technology related to renewable energy systems.

Description:

- 1. IoT communication technologies. Sifox, Lora, XBee, LTE-M, LTE- NB
- 2.- IoT network architecture: ZigBee. Network topologies.
- 3.- Hardware Requirements: XBee modules.
- 4.- Operating modes. XBee modules configuration.
- 5.- Associated software: XCTU

Specific objectives:

- . Know about the main IoT technologies and their characteristics.
- . Know about the programming of the XBEE-based IoT modules.
- . Know about real examples of the use of these low-energy communication technologies.

Related competencies :

. CE2. Comprehension and containment of basic concepts concerning general rules of mechanic, thermodynamic, field of shafts and electromagnetism; and its diligence to solve engineering problems.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

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Full-or-part-time: 7h 30m Theory classes: 3h Practical classes: 1h 30m Guided activities: 1h Self study : 2h

GRADING SYSTEM

Theory note (NTe) = (EX1 + EX2) / 2

Thematic and laboratory activities (NATL) = 0.2 (NAT) + 0.8 (NL)

Project (Presentation plus report) (NP):

The project will be exposed by the group. The rest of the students who do not belong to the group that is presenting put a reasoned and written note that will be given to the teacher. This note together with the corrected assessment of the teacher will configure the appreciation note of the exhibition (Nexpos). The note of the report will be assessed by the teacher.

NExpos = 0.2 (Note rest of students) + 0.8 (Note correction teacher)

NP = 0.4 (NExpos) +0.6 (NReport)

Final grade (NF) = 0.5 (NTe) + 0.25 (NATL) + 0.25 (NP)



BIBLIOGRAPHY

Basic:

- Hart, Daniel W. Electrónica de potencia. Madrid [etc.]: Prentice Hall, 2001. ISBN 8420531790.

- Alcor Cabrerizo, Enrique. Instalaciones solares fotovoltáicas. 4a ed. Sevilla: PROGENSA, 2008. ISBN 9788495693457.

- Ogata, Katsuhiko. Ingeniería de control moderna [on line]. 5a ed. Madrid [etc.]: Pearson Prentice Hall, 2010 [Consultation: 16/02/2024]. Available on:

https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1259. ISBN 9788483226605.

- Rashid, Muhammad H. Electrónica de potencia [on line]. 4a ed. México, D.F: Pearson, 2015 [Consultation: 19/02/2024]. Available on: <u>https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB BooksVis?cod primaria=1000187&codigo libro=6191</u>. ISBN 9786073233286.

- Méndez Muñiz, Javier María. Energía eólica. Madrid: Fundación Confemetal, 2012. ISBN 9788493961817.

Complementary:

- Juana Sardón, José María de. Energías renovables para el desarrollo. Madrid: ITES-Paraninfo, 2002. ISBN 9788428328647.

RESOURCES

Other resources:

Photovoltaic solar energy: concepts and applications. Barcelona: Institut Català d'Energia.

Power Electronics, Daniel Hart. Ed Prentice Hall

Power Electronics: Circuits, Devices and Applications, M. Rashid.

Solar energy: construction and assembly of equipment for electrical applications / RÖBKE-DOERR, Peter. Barcelona

Class notes.

Course notes.