Universidad de Alcalá

TEACHING GUIDE

Electronics for Renewable Energy

Degree in
Electronic Communications Engineering (GIEC)

Universidad de Alcalá

Academic Year 2023/2024

4th Year - 1st Semester (GIEC)

Approved by the School Board on June 12th, 2023

TEACHING GUIDE

Course Name:	**Electronics for Renewable Energy**
Code:	**370014 (GIEC)**
Degree in:	**Electronic Communications Engineering (GIEC)**
Department and area:	**Electrónica** **Electronic Technology**
Type:	**Optional (Oriented) (GIEC)**
ECTS Credits:	**6.0**
Year and semester:	**4th Year - 1st Semester (GIEC)**
Teachers:	Francisco Javier Rodríguez Sánchez. Emilio J. Bueno Peña
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	Spanish/ English Friendly

1. COURSE SUMMARY

Electronics for Renewable Energy aims to ensure that students learn the basics of the application of electronics to the development of power generation systems from renewable sources.

The course will focus on aspects such as the application of power electronics supplemented with the control electronics and the use of communications.

The knowledge learned in this course is finalist, since there are a range of jobs that can be accessed with the contents taught in it. In order to take advantage of the course, it is essential to have passed the subjects on Power Electronics and Electronic Control.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

en_TR1 - Knowledge, understanding and ability to apply the necessary legislation during the development of the profession of Technical Engineer of Telecommunication and ease of handling specifications, regulations and mandatory rules.

en_TR3 - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

en_TR5 - Easy to handle specifications, regulations and mandatory standards.

en_TR8 - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

en_CSE3 - Ability to perform the specification, implementation, documentation and set-up of equipment and systems, electronic, instrumentation and control, considering both the technical aspects and the corresponding regulatory regulations.

en_CSE4 - Ability to apply electronics as a support technology in other fields and activities, and not only in the field of Information Technology and Communications.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- **RA1**: To know and understand the scientific and mathematical principles underlying the generation of energy from renewable sources.
- **RA2**: Understand the grid connection regulations for distributed generation systems.
- **RA3**: Analyze and understand the functioning of the electronic systems used in renewable energy systems.

3. CONTENTS

Contents Blocks	Total number of hours
Introduction to renewable energy sources. Revision of the grid codes for the connection of renewable energies to the electricity grid.	5 hours
Photovoltaic Energy. Power Electronics converters topologies for photovoltaic systems. Network connection with Transformer. Non-transformer network connection.	20 hours
Wind Energy. Control of wind turbines. Power converters in wind power conversion systems. Fixed-speed wind turbines based on induction generators. Variable speed wind turbines based on doubly powered asynchronous generators, full-power asynchronous generators and synchronous generators	30 hours
Communications systems in renewable energy plants	3 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 h
Number of student work on their own:	92 h
Total hours	150 h

4.2. Methodological strategies, teaching materials and resources

In the teaching-learning process the following training activities will be held:

- Lectures (theoretical classes): large groups
- Practical classes (problems solving): large groups
- Lab classes: small groups
- Tutorships: individual and/or group
- Student work, before and after classes. This work will be supported by the information available for each topic at the website of the course (UAH Virtual platform)

In coordination with the lectures, practical classes oriented to problem solving and lab classes, where students can apply the acquired control concepts to real and/or simulated prototypes, are proposed.

To carry out the practice, the student will have the required material for digital implementation of control solutions: a computer with design/simulation tools, electronic cards and mechatronic platform to be controlled. Plant and controller are linked by an Ethernet network.

Students will be provided throughout the semester with tutorship in group (if requested by the students themselves) or individual. Whether individually or in small groups, this tutorship will resolve doubts and consolidate the acquired knowledge. Also it will help to make appropriate monitoring and assess the proper functioning of the mechanisms of teaching and learning.

Finally, the whole development of the subject will be detailed on the website of the course (UAH Virtual platform). All resources developed for the subject, such as slides, exercise statements and solutions, statements of problems for practices, detailed schedules for each group and class, mid-term exams marks and any other information that teachers consider appropriate for the proper teaching-learning process will be available on the website.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

The evaluation of the learning process for those students who do not request non-continuous assessment or whose application is refused will be done, by default, according to the model of continuous assessment, described in following paragraphs.

Continuous assessment implies and/or allows for the following:

- The student knows, by means of real and objective tests, his evaluation criteria.
- The student knows regularly the results of his learning process.
- Provide the teacher with objective information about subject evolution

Intermediate tests release contents from the final test.

According to current UAH regulations (rules governing the processes of learning assessment approved by the Governing Council of March 24, 2011, Article 6, paragraph 4), and, as long as the laboratory module is considered as an essential part to reach the capacities aimed by the Electronic Control Engineering course, attendance to all the lab practices, as well as successfully completing them, is considered as an essential and also compulsory element for the course assessment, either under continuous assessment or final evaluation format. For this reason, lab practices are common and mandatory, both for continuous and final assessment too.

5.2. EVALUATION

EVALUATION CRITERIA

Evaluation criteria must address the degree of acquisition of learning outcomes by the student. For this purpose, the following criteria are defined:

CE1: The student shows ability and initiative for modeling real systems, identifying linear and nonlinear components.

CE2: The student can perform the complete design of reference tracking system for a multivariable plant compensating for external disturbances.

CE3: The student demonstrates his availability to design deterministic observers as part of a complete multivariable control system.

CE4: The student is able to integrate knowledge of electronics, communications and control theory and apply them in real implementation.

CE5: The student has acquired sufficient technical knowledge to compare simulated and experimental results of a multivariable control system.

GRADING TOOLS

The following assessment tools will be used:

1. Ordinary call:

1.a) Continuous assessment: The theoretical part of the course will be evaluated by two exams (PEI and PEF). The lab part will be evaluated by performing two practices with their corresponding deliverable (EPL1 and EPL2) and individual defence. The final exam (PEF) will include some questions about lab part.

1.b) Non-Continuous assessment: The theoretical part will consist of a single exam covering all theoretical learning outcomes set for the course. The practical part will consist of the design and implementation of a final practice covering all practical learning established for the course.

2. Extraordinary call:

2.a) Theoretical part. It will consist of a single exam covering all theoretical learning outcomes set for the course.

2.b) Practical part. It will consist of the design and implementation of a final practice covering all practical learning established for the course.

- **Partial Evaluation Test (PEI)**. It consists of a theoretical examination with two parts:

  a. Test that includes basic aspects of the contents developed in class.
  b. Exercises related to the analysis and design of electronics for renew able generation systems.

- **Laboratory practice deliverables (EPL1 and EPL2)** The deliverables consist of the report that collects the work done by the student in the laboratory sessions, including the critical analysis of the results.

- **Final Evaluation Tests (PEF)**: Both in theory and in practice, students must jointly demonstrate the expected learning outcomes.

GRADING CRITERIA

Continuous assessment, ordinary call.

Skill	Learning Outcomes	Evaluation criteria	Grading tool			Contribution to the final mark
TR1, TR3, TR5 CSE3, CSE4	RA1, RA2	CE1, CE2, CE3	PEI	Test	PEF	7,5%
				Exercises		17,5%
			PEF	Test		7,5%
				Exercises		17,5%
TR5, TR8, CSE3, CSE4	RA3	CE4	EPL1		PEF	25%
			EPL2			25%

Students shall be deemed to have passed the course (demonstrating the achievement of the theoretical and practical learning outcomes) following continuous assessment if these requirements are met:

- Have successfully passed the theoretical exams (PEI and PEF). It means that a student satisfactorily achieves the results of theoretical learning if its rating on the set of theoretical exams is equal to or greater than 50% of the maximum possible score.
- Have successfully passed laboratory practices (EPLs and PEF). It means that a student successfully acquires the results of practical learning, if he/she attends at least 80% of the laboratory sessions, completes all practices and his/her related exam score is equal to or greater than 50% of the maximum obtainable score.
- The final mark, having passed the theoretical part and the practical part will result from the weighted average of both.
- Students who follow the model of continuous assessment and are evaluated on two or more exams of the four possible (2 PEI, 2 EPL) shall be considered submitted (presented) in the ordinary call.

Final assessment, ordinary call

Skill	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
TR1, TR3, TR5, CSE3, CSE4	RA1, RA2	CE1, CE2, CE3	PEF	50%
TR5, TR8, CSE3, CSE4	RA3	CE4	PEF	50%

Students shall be deemed to have passed the course (demonstrating the achievement of the theoretical and practical learning outcomes) if both parts, theory and laboratory, are independently overcome. The final mark is the average of the scores of both parts.

Final assessment, extraordinary call

Skill	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
TR1, TR3, TR5, CSE3, CSE4	RA1, RA2	CE1, CE2, CE3	PEF	50%
TR5, TR8, CSE3, CSE4	RA3	CE4	PEF	50%

As for the ordinary call, students shall be deemed to have passed the course (demonstrating the achievement of the theoretical and practical learning outcomes) if both parts, theory and laboratory, are independently overcome. The final mark is the average of the scores of both parts.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

1. Documentation explicitly prepared by the teaching staff for the subject, which will be provided to the students directly, or with their publication on the subject's website.

2. Webpage on the subject of the course that will be previously selected by the faculty.

6.2. Additional Bibliography

General information

- Stephen Peake. Renewable Energy: power for a sustainable future. Oxford University Press, 2017.
- B. K. Bose. Power Electronics in Renewable Energy Systems and Smart Grid: Technology and Applications. Wiley-IEEE Press, 2019.
- F. Jarabo, N. Elortegui. Energías Renovables. S.A.P.T. Publicaciones Técnicas S.L., 2000.
- F. Jarabo, N. Elortegui, J. Jarabo. Fundamentos de Tecnología Ambiental. S.A.P.T. Publicaciones Técnicas S.L., 2000.

Wind energy

- B. Wu, Y. Lang, N. Zargari, S. Kouro. Power Conversion and Control of Wind Energy Systems. Wiley-IEEE Press, 2011.
- S. Heier. Grid Integration of Wind Energy Conversion Systems. John Wiley & Sons, 1998.
- P. Gipe. Energía Eólica Práctica. PROGENSA, 2000.

Photovoltaic energy

- Y. Yang, K.A. Kim, F. Blaabjerg, A. Sangwongwanich. Advances in grid-connected photovoltaic power conversion systems. Woodhead Publishing, 2018.
- J. Cantos Serrano. Configuración de instalaciones solares fotovoltaicas, 2.ª edición. Paraninfo, 2022.
- M. Castro, L. Dávila Gómez, A. Colmenar Santos. Sistemas Fotovoltaicos Conectados a Red: Estándares y Condiciones Técnicas. PROGENSA, 2000.
- E. Lorenzo. Electricidad Solar. Ingeniería de los Sistemas Fotovoltaicos. PROGENSA, 1994.

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Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.