Universidad de Alcalá

TEACHING GUIDE

Electronics for Renewable Energy

Degree in
Electronic Communications Engineering (GIEC)

Universidad de Alcalá

Academic Year 2024/2025

4th Year - 1st Semester (GIEC)

Approved by the EPS School Board on June 14th, 2024

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 Huerta Sánchez Daniel Santamargarita Mayor
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 carried out:

- Theoretical classes and resolution of examples.
- Practical classes: laboratory and resolution of exercises.
- Tutorials: individual and/or group.

In addition, the following complementary resources may be used, among others:

- Individual or group work: in addition to its realization, the corresponding public exhibition in front of the rest of the classmates to encourage debate.
- Attendance to conferences, meetings or scientific discussions related to the subject.

Throughout the course the student will be proposed theoretical and practical activities and tasks. Different practices will be carried out in coordination with the teaching of the theoretical concepts, so that the student can experiment both individually and in group, thus consolidating the acquired concepts.

For the realization of the practical part, the student will have in the laboratory a station with basic instruments (oscilloscope, power supply, signal generator), necessary hardware system as well as a computer with appropriate design and simulation software. At the beginning of the course the material that the students will have to acquire personally or in group for the realization of the practices will be published.

Throughout the learning process in the course, the student will have to make use of different bibliographic or electronic sources and resources, so that he/she becomes familiar with the documentation environments that he/she will use professionally in the future.

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 (Learning Assesment Guidelines, LAG, 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 Learning Assesment Guidelines 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.

Ordinary call

The evaluation in the ordinary call must be inspired by the continuous evaluation criteria, always taking into account the achievement of the learning outcomes established for the subject.

Continuous evaluation:

The theoretical part of the subject will be evaluated by means of:

- partial evaluation test (PEI)
- final evaluation test (PEF)

The practical part will be evaluated by means of a laboratory project with its corresponding deliverable (EPL1) and presentation (EPL2) to the class. This project can be done in groups.

The final evaluation test (PEF) will consist of a final exam that will cover all the learning outcomes established for the subject.

Extraordinary call

a. Theoretical part. It will consist of a single exam covering all the theoretical learning outcomes established for the subject.
b. Of the practical part. It will consist of the design and realization of a final laboratory practice that covers all the practical learning outcomes established for the course.

In order to take advantage of the final evaluation process, the student must request it in writing to the director of the center within the first two weeks of his/her incorporation, indicating the reasons that prevent him/her from following the continuous evaluation system. The director of the center will communicate the resolution within a maximum of 15 days. If no response is received, the request will be considered accepted.

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 a practical project with their corresponding deliverable (EPL1) and oral defence (EPL2). 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 exam where the student has to solve exercises and theoretical questions related to the analysis and design of electronics for renewable generation systems.
- **Project deliverable and presentation to the class (EPL1, EPL2)** The deliverable (EPL1) consists of a report of the work done by the student in the project sessions, including the critical

analysis of results. Likewise, the student will defend the project before the rest of the class (EPL2).

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

GRADING CRITERIA

Continuous assessment, ordinary call.

<table>
<tr><th>Skill</th><th>Learning Outcomes</th><th>Evaluation criteria</th><th colspan="2">Grading tool</th><th>Contribution to the final mark</th></tr>
<tr><td rowspan="2">TR1, TR3, TR5, CSE3, CSE4</td><td rowspan="2">RA1, RA2</td><td rowspan="2">CE1, CE2, CE3</td><td>PEI</td><td rowspan="2">PEF</td><td>25%</td></tr>
<tr><td>PEF</td><td>25%</td></tr>
<tr><td rowspan="2">TR5, TR8, CSE3, CSE4</td><td rowspan="2">RA3</td><td rowspan="2">CE4</td><td>EPL1</td><td rowspan="2">PEF</td><td>30%</td></tr>
<tr><td>EPL2</td><td>20%</td></tr>
</table>

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 satisfactorily passed the laboratory project (EPL1 and 2). It will be understood that a student satisfactorily acquires the practical learning outcomes, if he/she attends at least 80% of the project sessions, completes the practical project and his/her weighted grade in the related tests is equal to or higher than 50% of the maximum obtainable grade.
- 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 (PEI, PEF and 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%

The student will be considered to have passed the course (demonstrating the achievement of the theoretical and practical learning outcomes) if both parts, theory and laboratory, are passed independently. The final grade will be 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.

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.