Course guide
320162 - IXESER - Grid Integration of Renewable Energy Systems

Last modified: 02/04/2024

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: J. IGNACIO CANDELA

Others:

PRIOR SKILLS

It is considered very convenient to have passed before the subject of Electrical Systems.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. ELE: Applied knowledge on renewable energy.

CE29. (ENG) ELE: Coneixements i capacitats per aprofundir en tecnologies específiques de l'àmbit.

TEACHING METHODOLOGY

- Classroom sessions in which the teacher will present the concepts, propose and guide the work group.
- Group work where students, in groups of 2, will prepare practicals and performs reports. Also, in groups of 2, they develop projects, which must be defended in a public session.
- Independent study in which students assimilate the concepts raised, perform the proposed work and prepare lessons.

LEARNING OBJECTIVES OF THE SUBJECT

The objective of the course is to study the distributed generation systems, to identify emerging issues with it and thus understand the requirements for the correct integration of renewable energies into the grid.
The course is divided into 5 topics. In the first topic the dynamic power system including distributed generation is studied. First the classic electric system is described, then the most common distributed generation technologies are described and finally the interactions between them depending on its type of connection.
The second topic covers the inclusion of energy storage system on the grid. First from the point of view of technologies, then from the point of view of the performance that the storage system can provide to the grid.
The third topic studies photovoltaic systems, the technical requirements for grid connection, specific structures of investors and their control, the island detection systems and tracking of the maximum power point.
The fourth topic studies wind systems, the technical requirements for connection to grid, the configurations of wind farms, wind inverters structure and its control.
It also aims to familiarize students with modeling and simulation of power systems with distributed generation based on renewable energy, focusing the study on wind and photovoltaic systems, but extending the concept to other primary energy sources.
The course presents a high work in the laboratory, where students can put into practice the knowledge acquired through the simulation of power electronic systems applied to renewable energy.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	30,0	20.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

TOPIC 1. - Dynamics of distributed generation power systems

Description:
Introduction
- Presentation
- Objectives of the course
Operation of the classic electric system
- Historical development of the electrical system
- Control System
- Dynamic response of the electrical system
Distributed generation
- Wind generation
- Photovoltaic generation
- Other technologies
- Effect on the grid
Interconnection generation-grid
- Connection with synchronous generator
- Connection with asynchronous generator
- Electronic connection VSC
- Inverter Control
- Synchronization
- Grid supporting from inverters

Related activities:
Practice P0. - Introduction to modeling electrical systems.
Practice P1. - Modeling a classic generation plant.

Full-or-part-time: 50h
Theory classes: 10h
Laboratory classes: 10h
Self study : 30h

TOPIC 2. - Energy Storage

Description:
Technologies
- Mechanical Systems
- Electrochemical Systems
- Electrical Systems
- Thermal Systems
Energy storage for power system applications
- Grid Side
- Renewables
- Demand Side
- Other factors

Related activities:
Practice P2. - Generation with asynchronous machines.

Full-or-part-time: 25h
Theory classes: 5h
Laboratory classes: 5h
Self study : 15h

TOPIC 3. - Grid integration of photovoltaic systems

Description:
Requirements for photovoltaic systems
- Interconnection requirements
- Power Quality
- Anti-island
- Structure of PV inverters
- Detection of island
Structure of PV inverters
- Structure
- Investors and modulation
- Control
Island detection and MPPT
- Introduction
- Passive Methods
- Active methods
- MPPT

Related activities:
Practice P3. - Connection to grid through electronic converters
Assignment 1. - Additional services converters

Full-or-part-time: 25h
Theory classes: 5h
Laboratory classes: 5h
Self study : 15h

TOPIC 4. - Grid integration of wind systems

Description:
Requirements for wind systems
- Grid Codes for wind turbines
- Control of active power
- Control of the reactive power
- Frequency Control
- Operating Range
- LVRT
- Future trends
Wind Turbines structures
- Configuration turbine
- Topology converters
Turbine Control

Related activities:
Practice P4. - Feasibility study of an isolated renewable facility
Assignment 2 -. Sizing and design of equipment

Full-or-part-time: 30h
Theory classes: 6h
Laboratory classes: 6h
Self study : 18h

TOPIC 5. - Advanced topics in grid integration

Description:
- The electric vehicle in the grid
- Load management
- HVDC interconnection
- STATCOM and filters Assets
- FACTS and UPFC

Specific objectives:
- Understanding other grid elements that may affect the integration
- Understand the new electronic elements that facilitate grid management

Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study : 12h

GRADING SYSTEM

Written examinations 50 % (1st exam: 25%; 2nd exam: 25%)
Presented works: 30%
Lab: 20%

EXAMINATION RULES.

The exams are about the theoretical knowledge of the subject and is allow bring the information considered appropriate.
The practices must be delivered in report format and content must be defended against the teacher. In the appropriate case, the previous work over the practical is also considered.
Projects will defend and rated in a public meeting, the projects refers to the application portion of the course

BIBLIOGRAPHY

Basic:
- Teodorescu, R.; Liserre, M.; Rodríguez, P. Grid converters for photovoltaic and wind power systems [on line]. Wiley, 2011 [Consultation: 09/05/2022]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9780470667057. ISBN 9780470057513.

Complementary:
- Kundur, P. S.; Malik, O. P. Power system stability and control. 2nd ed. New York: McGraw-Hill, 2022. ISBN 9781260473544.
- Machowski, J.; Bumby, J.R.; Bialek, J.W. Power system dynamics: stability and control. 2nd ed. Chichester: Wiley, 2008. ISBN 9780470725580.
- Farret, F. A.; Simões, M. G. Integration of alternative sources of energy [on line]. Hoboken: John Wiley and Sons, 2006 [Consultation: 09/05/2022]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/0471755621. ISBN 9780471712329.
- Bollen, M.H.J.; Hassan, F. Integration of distributed generation in the power system. Hoboken, New Jersey: Wiley-IEEE Press, 2011. ISBN 9780470643372.
- Keyhani, A.; Marwali, M.N.; Dai, M. Integration of green and renewable energy in electric power systems. Hoboken: Wiley, 2010. ISBN 9780470187760.

RESOURCES

Other resources:
International Electrotechnical Commission, White Paper, Grid integration of large-capacity Renewable Energy sources and use of large-capacity electrical Energy Storage, http://www.iec.ch/whitepaper/pdf/iecWP-gridintegrationlargecapacity-LR-en.pdf