



## Course guide

### 820753 - QSIRX - Power Quality

**Last modified:** 16/04/2024

**Unit in charge:** Barcelona School of Industrial Engineering  
**Teaching unit:** 709 - DEE - Department of Electrical Engineering.

**Degree:** MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Optional subject).  
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).  
MASTER'S DEGREE IN ELECTRIC POWER SYSTEMS AND DRIVES (Syllabus 2021). (Optional subject).  
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

**Academic year:** 2024    **ECTS Credits:** 5.0    **Languages:** Catalan, Spanish, English

#### LECTURER

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**Coordinating lecturer:** Joan Montañá Puig

**Others:** Luis Sainz Sapera

#### PRIOR SKILLS

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- Basic knowledge of electrical systems.
- Solve circuit theory problems.
- Formulate Fourier series.
- Knowledge of electric power systems.

#### REQUIREMENTS

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#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.

CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.

CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.



## TEACHING METHODOLOGY

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- Lecture or seminar (EXP): Teacher and invited lectures.
- Participatory classes (PART): Exercises solved by groups and debates. Presentations of activities (individual or in groups).
- Theoretical and practical work (TD): Solution of exercises or case studies with the assessment of the teacher.
- Short project work (PR): short project or case study where the student will apply the studied contents.
- Project work (PA): in this case the student will work in group. A report with a description of the problem, the proposed solutions and conclusions will be submitted.
- Evaluation activities (EV).

## LEARNING OBJECTIVES OF THE SUBJECT

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At the end of the course the students should be able to:

- Identify the effects of different types of disturbances and the most common mitigation techniques.
- Understand the origin of the harmonics, assess its effects and propose solutions.
- Understanding the origin, magnitude and effects of transients. Study of mitigation.
- Know the quality parameters of the voltage supply. Study of variations in voltage and frequency.
- Identify the origin, modelling and understand the impact of interruptions and voltage sags.
- knowing the regulatory framework, with special attention to the renewable generation.

## STUDY LOAD

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Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	30,0	24.00
Hours small group	15,0	12.00

**Total learning time:** 125 h

## CONTENTS

### 1. Introduction

**Description:**

This module describes the concepts of power quality in electrical systems, electromagnetic compatibility, a general classification of the disturbances and the related regulations will be introduced. The emphasis will be on systems with renewable energy sources.

**Contents:**

- 1.1 Concepts of power quality.
- 1.2 Types of disturbances in electrical systems.
- 1.3 Origin and classification of disturbances (EMC).
- 1.4 Effects of the integration of renewable energy into the grid.
- 1.5 Current regulatory framework.

**Specific objectives:**

- Understand the concepts related to the power quality.
- Know the types and sources of the disturbances affecting the quality of supply.
- To characterize the disturbances.
- Understand the current regulatory environment.

**Related activities:**

- Activity 1
- Activity 2

**Full-or-part-time:** 13h

Theory classes: 3h

Self study : 10h

### 3. Periodic perturbations

**Description:**

In the second module periodic disturbances will be studied. The origin of harmonics and their effects on the quality of supply and consumption will be considered. Identification and mitigation techniques will be presented. The cases of renewable energy sources integrated to the power network will be exposed.

**Specific objectives:**

- To identify the source of harmonics.
- To Frequency domain modeling of power systems and evaluate the effects to the power quality
- To know the most common mitigation techniques.

**Related activities:**

- Activity 1
- Activity 2
- Activity 5

**Full-or-part-time:** 39h 30m

Theory classes: 4h 30m

Laboratory classes: 5h

Guided activities: 5h

Self study : 25h



### 3. Non-periodic disturbances

**Description:**

The third module is devoted to non-periodic disturbances. First, temporary and transient over voltages will be discussed. Over voltages caused by direct and indirect lightning will be evaluated. Lightning effects to wind energy will be presented. Second, voltage and frequency variations will be studied. Finally, interruptions and voltage sags will be exposed. How renewable energy sources affects to the non-periodic disturbances will be described during this module.

**Specific objectives:**

- To understand the source, magnitude and effects of transient over voltages. To know the most common mitigation techniques.
- To know the quality characteristics of the voltage supply. To study the variations of voltage and frequency.
- To identify the origin, model and understand the impact of interruptions voltage sags.

**Related activities:**

- Activity 1
- Activity 3
- Activity 4
- Activity 5

**Full-or-part-time:** 72h 30m

Theory classes: 7h 30m

Laboratory classes: 10h

Guided activities: 10h

Self study : 45h

## GRADING SYSTEM

- Test (Activity 5): 50 %
- Exercises and works (Activity 1): 25 %
- Laboratory and practices (Activities 2, 3 i 4): 25 %

## EXAMINATION RULES.

Rules will be available in Atena

## BIBLIOGRAPHY

**Basic:**

- Bollen, Math H.J. Understanding power quality problems : voltage sags and interruptions. New York: Wiley-IEEE Press, 1999. ISBN 0780347137.
- Dugan, Roger C. Electrical power systems quality. 3rd ed. New York: McGraw-Hill, 2012. ISBN 9780071761550.
- Moreno Muñoz, A. Power quality : mitigation technologies in a distributed environment [on line]. London: Springer, cop. 2007 [Consultation: 01/09/2022]. Available on: <https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-1-84628-772-5>. ISBN 9781846287718.
- Arrillaga, J.; Watson, N. R. Power system harmonics [on line]. 2nd ed. West Sussex, England: J. Wiley & Sons, cop. 2003 [Consultation: 31/05/2019]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=189878>. ISBN 0470851295.

**Complementary:**

- UNE-EN 50160: Características de la tensión suministrada por las redes generales de distribución. AENOR,
- UNE-EN 61000 Compatibilidad electromagnética (CEM). AENOR,
- IEEE Standard 1410 : guide for improving the lightning performance of electric power overhead distribution lines [on line]. IEEE, 2011 [Consultation: 13/09/2022]. Available on: <http://ieeexplore.ieee.org/document/5706451/>. ISBN 9780738164878.
- IEEE Standard 1250 : guide for service to equipment sensitive to momentary voltage disturbances [on line]. IEEE, 1995 [Consultation: 13/09/2022]. Available on: <http://ieeexplore.ieee.org/document/467536/?reload=true>. ISBN 9780738103839.
- IEEE Standard 1159: Recommended practices for monitoring electric power quality, [on line]. IEEE, 1995 [Consultation:



06/09/2017]. Available on: <http://ieeexplore.ieee.org/recursos.biblioteca.upc.edu/document/475495/>.

- IEEE Standard 519: Recommended practices and requirements for harmonic control in electrical power systems [on line]. IEEE, 2014 [Consultation: 13/09/2022]. Available on: <https://ieeexplore.ieee.org/document/6826459>. ISBN 9780738190051.

- Ministerio de Industria, Turismo y Comercio. "Real Decreto 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial". Boletín Oficial del Estado [on line]. «BOE» núm. 126, de 26/05/2007 [Consultation: 13/12/2024]. Available on: <https://www.boe.es/buscar/act.php?id=BOE-A-2007-10556>.