

## 820141 - ASEPE - Analysis of Electrical Power Systems

Coordinating unit:	295 - EEBE - Barcelona East School of Engineering
Teaching unit:	709 - EE - Department of Electrical Engineering
Academic year:	2018
Degree:	BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional) BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Optional) BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional) BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits:	6
Teaching languages:	Catalan, Spanish

### Teaching staff

Coordinator: JUAN JOSÉ MESAS GARCÍA

Others: JUAN JOSÉ MESAS GARCÍA

### Opening hours

Timetable: Specified by the professor during their first class, and then available in Atenea.

### Prior skills

Students of Bachelor's degree in Electrical Engineering: Those acquired in the subjects CALCULUS, ALGEBRA AND MULTIVARIABLE CALCULUS, NUMERICAL CALCULUS - DIFFERENTIAL EQUATIONS, ELECTRICAL SYSTEMS, CIRCUITS AND SIGNALS, ELECTRICAL MACHINES I / II, LOW AND HIGH VOLTAGE ELECTRICAL INSTALLATIONS I / II, ELECTRIC POWER SYSTEMS.

Students of Bachelor's degree in Energy Engineering: Those acquired in the subjects CALCULUS, ALGEBRA AND MULTIVARIABLE CALCULUS, NUMERICAL CALCULUS - DIFFERENTIAL EQUATIONS, ELECTRICAL SYSTEMS, ELECTRICAL ENERGY GENERATION, ELECTRICAL ENERGY TRANSMISSION AND DISTRIBUTION.

### Requirements

Students of Bachelor's degree in Electrical Engineering: To have passed the subjects CALCULUS, ALGEBRA AND MULTIVARIABLE CALCULUS, NUMERICAL CALCULUS - DIFFERENTIAL EQUATIONS, ELECTRICAL SYSTEMS, CIRCUITS AND SIGNALS, ELECTRICAL MACHINES I / II, LOW AND HIGH VOLTAGE ELECTRICAL INSTALLATIONS I / II, ELECTRIC POWER SYSTEMS.

Students of Bachelor's degree in Energy Engineering: To have passed the subjects CALCULUS, ALGEBRA AND MULTIVARIABLE CALCULUS, NUMERICAL CALCULUS - DIFFERENTIAL EQUATIONS, ELECTRICAL SYSTEMS, ELECTRICAL ENERGY GENERATION, ELECTRICAL ENERGY TRANSMISSION AND DISTRIBUTION.

### Degree competences to which the subject contributes

Specific:

CEELE-24. Understand electrical power systems and their applications.

Transversal:

07 AAT N1. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

07 AAT N2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers.

Devoting the time needed to complete each task, including personal contributions and expanding on the

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recommended information sources.

### Teaching methodology

The teaching methodology used in this subject can be divided into three parts:

- Master classes: theory and problems (30%)
- Laboratory sessions (10%)
- Individual work based learning (60%)

### Learning objectives of the subject

To provide knowledge on the analysis and operation of electric power systems:

- Load flow study.
- Stability analysis.
- Economic operation of power systems.

### Study load

Total learning time: 150h	Hours large group:	45h	30.00%
	Hours medium group:	0h	0.00%
	Hours small group:	15h	10.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

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### Content

#### 1. Load flow study

Learning time: 52h 30m

Theory classes: 15h

Laboratory classes: 7h 30m

Self study : 30h

#### Description:

- 1.1. Introduction.
- 1.2. Multiport representation of a power system.
  - 1.2.1. Basic concepts.
  - 1.2.2. Bus admittance matrix.
- 1.3. Formulation of the load flow problem.
  - 1.3.1. Classification of variables.
  - 1.3.2. Power equations.
  - 1.3.3. Classification of buses.
- 1.4. Resolution of the load flow problem.
  - 1.4.1. General solution of the load flow problem.
  - 1.4.2. Calculation of bus voltages.
    - 1.4.2.1. Gauss-Seidel method.
    - 1.4.2.2. Newton-Raphson method.
    - 1.4.2.3. Fast decoupled method.
- 1.5. Linearized or DC load flow.
- 1.6. Power flow control.

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<h3>2. Stability analysis</h3>	<p>Learning time: 52h 30m</p> <p>Theory classes: 15h Laboratory classes: 7h 30m Self study : 30h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>2.1. Introduction.</li> <li>2.2. Electrical equations of a synchronous machine.</li> <li>2.3. Power system response to big disturbances (transient stability). <ul style="list-style-type: none"> <li>2.3.1. Motion equations of a synchronous machine.</li> <li>2.3.2. Generator - infinite power bus systems.</li> <li>2.3.3. Numerical resolution of the motion equations.</li> <li>2.3.4. Multimachine systems.</li> </ul> </li> <li>2.4. Power system response to small disturbances (steady-state stability). <ul style="list-style-type: none"> <li>2.4.1. Generator - infinite power bus systems.</li> <li>2.4.2. Multimachine systems.</li> </ul> </li> <li>2.5. Methods to improve power system stability.</li> </ul>	
<h3>3. Economic operation of power systems</h3>	<p>Learning time: 45h</p> <p>Theory classes: 15h Laboratory classes: 0h Self study : 30h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>3.1. Introduction.</li> <li>3.2. Nonlinear function optimization. <ul style="list-style-type: none"> <li>3.2.1. Function optimization without constraints.</li> <li>3.2.2. Function optimization with equality constraints.</li> <li>3.2.3. Function optimization with inequality constraints.</li> </ul> </li> <li>3.3. Economic dispatch of generation. <ul style="list-style-type: none"> <li>3.3.1. Operating costs of thermal generation.</li> <li>3.3.2. Economic dispatch neglecting losses.</li> <li>3.3.3. Economic dispatch neglecting losses and including generator limits.</li> <li>3.3.4. Economic dispatch including losses.</li> </ul> </li> </ul>	

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### Qualification system

The final Mark of the Subject ( $N_{Asig}$ ) is calculated, rounded to the nearest tenth, using the formula

$$N_{Asig} = \text{MAX} (0.25 \cdot N_{ExPar} + 0.55 \cdot N_{ExFin} + 0.20 \cdot N_{Prac} ; 0.80 \cdot N_{ExFin} + 0.20 \cdot N_{Prac})$$

where

$N_{ExPar}$  is the Midterm Exam Mark

$N_{ExFin}$  is the Final Exam Mark

$N_{Prac}$  is the Practice Mark

IMPORTANT REMARK: This subject does NOT have a Re-assessment Exam.

### Regulations for carrying out activities

- The Midterm Exam and the Final Exam are individual, in-person and written.
- In addition to writing utensils, it is only permitted to have one sheet with formulas (a single original handwritten A4 sheet) to be delivered to the professor at the end of each of the exams, and a calculator without external connectivity (no mobile phone or tablet can be used as such).
- Maximum punctuality is kindly requested.

### Bibliography

Basic:

Gómez Expósito, Antonio. Análisis y operación de sistemas de energía eléctrica. Madrid [etc.]: McGraw Hill Interamericana, 2002. ISBN 944813592X.

Grainger, John J.; Stevenson, William D., Jr.. Análisis de sistemas de potencia. México [etc.]: McGraw-Hill Interamericana, 1996. ISBN 9701009088.

Barrero, Fermín. Sistemas de energía eléctrica. Madrid: Paraninfo, cop. 2004. ISBN 8497322836.

Ramírez Rosado, Ignacio J. [et al.]. Problemas resueltos de Sistemas de Energía Eléctrica. Madrid: Paraninfo, cop. 2014. ISBN 8497324083.