# 820016 - STE - Electrical Systems

**Coordinating unit:** 295 - EEBE - Barcelona East School of Engineering  
**Teaching unit:** 709 - EE - Department of Electrical Engineering  
**Academic year:** 2019  
**Degree:**  
- BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)  
**ECTS credits:** 6  
**Teaching languages:** Catalan, Spanish, English

### Teaching staff

**Coordinator:** JUAN ANTONIO GARCÍA-ALZÓRRIZ PARDO - RODOLFO OSEIRA GOAS  
**Others:** Primer quadrimestre:  
- HERMENEGILDO ALTELARREA SORIA - M11, M12, M23, M31, M32  
- JAIME BUSTO ABADIA - M43, M44  
- JUAN CRUZ VAQUER - M13, M14, T21, T22, T23, T24  
- JORGE EL MARIACHET CARREÑO - M11, M12, M13, M14, T21, T22  
- ENRIC FERRER BARDEM - M41, M42, T12, T13, T14  
- JUAN ANTONIO GARCÍA-ALZÓRRIZ PARDO - M24, M31, M32, M33, M34, M35, M41, M42, M43, M44, M45, T11  
- RODOLFO OSEIRA GOAS - M21, M22, M23, M24, M33, M34, T11, T12, T13, T14  
- JOSEP SEGARRA MULLERAT - T23, T24

### Opening hours

**Timetable:** Office of the teacher. See timetable in each case.

### Prior skills

Those from previous semesters.

### Requirements

None.

### Degree competences to which the subject contributes

**Specific:**
1. Understand and apply the theory of electrical circuits and machines.

**Transversal:**
2. **EFFICIENT ORAL AND WRITTEN COMMUNICATION** - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.

**Teaching methodology**

The course is divided in lectures (30%), individual work (30%), work in small groups (cooperative, collaborative or other) (20%), and project-based learning (20%).

The self-learning process is developed by using the Athena Digital Campus, which includes resources, self-assessment questionnaires, and specifications for a workgroup that has to be developed throughout the semester.

**Learning objectives of the subject**

**General objectives:**
- To acquire the basic knowledge of electricity and circuit theory applied to the study of electrical circuits and systems.
- To acquire basic knowledge of electricity applied to the design of low voltage electrical installations.
- To acquire basic knowledge of electrical machines and converters and be aware of its application in electrical systems.
- To acquire basic knowledge of electricity which enable the interpretation of diagrams, catalogs, technical specifications, low voltage directive and others regulations.
- To acquire the ability to learn autonomously new skills and techniques appropriate to the conception and design of electrical installations.

**Transversal competences:**
- To acquire the ability to learn autonomously new knowledge and techniques to engine and to design circuits.
- To acquire the ability to learn autonomously new skills and techniques appropriate to the conception and design of electrical installations
- Capacity for independent learning.
- To gain commitment and organizational skills to work with the group.
- To gain oral and written communication.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 45h</th>
<th>30.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group: 0h</td>
<td></td>
<td>0.00%</td>
</tr>
<tr>
<td>Hours small group: 15h</td>
<td></td>
<td>10.00%</td>
</tr>
<tr>
<td>Guided activities: 0h</td>
<td></td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study: 90h</td>
<td></td>
<td>60.00%</td>
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</tbody>
</table>
## Content

### Unit 1. introduction

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>3h 50m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>1h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Self study :</td>
<td>1h 20m</td>
</tr>
</tbody>
</table>

### Description:
1.2. Fundamental magnitudes: charge, current, voltage, power and energy. Unit systems.
1.4. Continuous and discrete signals.

### Related activities:
- Set of problems.
- Laboratory Practice: Basic laboratory instrumentation.

### Specific objectives:
At the end of the topic the student will be able to identify and learn:
- What is a system and an electrical circuit?
- What are the fundamental magnitudes of systems and electrical circuits?
- What are the elements of an electrical circuit and its properties?
- What is an electric model?
- What are the continuous and discrete signals?
## Unit 2. Resistive circuit analysis

**Learning time:** 27h 40m  
- Theory classes: 11h  
- Laboratory classes: 2h  
- Self study: 14h 40m

### Description:
- 2.4. Passive and active elements of a circuit.  
- 2.7. Linearity. Superposition theorem.  
- 2.8. Equivalent circuits.  
- 2.9. Thévenin's and Norton's theorems.  
- 2.10. Maximum power transfer theorem.

### Related activities:
- Set of problems.  
- Practice lab: experimental verification of the basic laws governing the operation of the electrical circuits.

### Specific objectives:
At the end of the topic the student will be able to learn and know:
- What is the resistor and how is its characteristic curve: current-voltage relationship?  
- How is the power in a resistor.  
- To know and to apply Ohm's and Kirchhoff's laws in resistive circuits.  
- How is the currents and voltages balancing of in a circuit.  
- What is a voltage divider and current divider?  
- What are the passive and active elements of a circuit and their differences?  
- To know and to apply Tellegen's theorem and how is the power balancing of in a circuit.  
- How to analyze the resistive circuits. Knowing how to use the methods of mesh analysis and nodal analysis.  
- What is the linearity and the superposition theorem and how to applied to circuit analysis?  
- What are equivalent circuits?  
- To know and to apply the Thévenin's and Norton's theorems.  
- To know and to apply the maximum power transfer theorem.

Learning time: 27h 40m
   Theory classes: 11h
   Laboratory classes: 2h
   Self study: 14h 40m

Description:
3.2. Euler's identities. Transformation of the sine function in the frequency domain (jw). Phasor concept. Transformation properties.
3.3. Domains of representation: time-domain and phasor representation.
3.4. Ohm's law and Kirchhoff's laws in the frequency-domain (jw).
3.7. Steady-state analysis of electrical circuits.
3.8. Power: instantaneous power, average power, active and reactive power. Apparent power and power factor. Complex power.
3.9. Reactive power compensation.
3.10. Maximum power transfer theorem.

Related activities:
· Set of problems.
· Practical laboratory: Test circuits in sinusoidal permanent regime. Study of tensions, currents and powers AC. Power factor correction.

Specific objectives:
At the end of the topic the student will be able to know:
· What is a periodic signal and what are their characteristic values?
· How is the transformation of a sinusoidal exciter function in the frequency-domain (jw)? What Phasor and as applied to the transformation properties of the analysis of circuits in sinusoidal steady-state?
· What are the domains of the signal representation: temporal and phasor representation?
· What are the phasor relationships of passive elements R, L and C. and how they behave in sinusoidal steady-state?
· How are the phasor diagrams?
· To know and to apply the Ohm's law and Kirchhoff's laws for sinusoidal steady state.
· What is the impedance and admittance and how to apply network reduction for sinusoidal steady-state?
· How to analyze circuits for sinusoidal steady state? Knowing how to use the mesh analysis and nodal analysis.
· What are the concepts of sinusoidal steady-state power?
· What is the power factor?
· How it applies the power factor correction?
· How is the theorem of the maximum power transfer in sinusoidal steady-state?
· To know and to apply the maximum power transfer theorem for sinusoidal steady-state.
Unit 4. Three-phase systems

Learning time: 27h 40m
   Theory classes: 11h
   Laboratory classes: 2h
   Self study: 14h 40m

Description:
4.1. Polyphase systems and three-phase systems.
4.2. Three-phase generator. Phase and line voltages. Relationship between phase and line voltages.
4.3. Load-phase: star connections and delta connections. Voltage and currents in star and delta connected loads. Millman’s theorem. Star-delta and delta-star conversion.
4.5. Single phase loads connected to a three phase power.
4.7. Reactive power compensation in three phase balanced systems.
4.8. Three-phase voltages, currents, and power measurement.

Related activities:
· Collection of problems.
· Laboratory Practice: Three-phase systems. Study of tensions, currents and powers at three-phase systems.

Specific objectives:
At the end of the topic the student will be able to know:
· What is a polyphase system?
· How a voltage phase is generated?
· What is the relationship between phase and line voltages?
· How are composed of three phase loads?
· How is transforms three-phase loads on star and delta?
· How to analyze networks with three-phase load balanced and unbalanced?
· How to connect Single phase load in three-phase networks?
· What are the concepts of three-phase power system?
· How it performs the power factor correction in three-phase balanced systems?
· What are the methods for measurements voltages, currents and power at three-phase systems?
# Unit 5. Single-phase and Three-phase transformers

<table>
<thead>
<tr>
<th>Learning time: 25h 40m</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 11h</td>
</tr>
<tr>
<td>Self study: 14h 40m</td>
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</tbody>
</table>

## Description:
- 5.1. The general principle of electromagnetic transformation.
- 5.2. Constitution and fundamental values.
- 5.3. Ideal single-phase transformer.
- 5.4. Real single-phase transformer.
- 5.5. Equivalent electrical circuit.
- 5.6. Ratings assigns.
- 5.7. Basic test on transformers.
- 5.8. Voltage drop.
- 5.9. Losses and performance.
- 5.11. Transformers three columns. Connection groups.

## Related activities:
- Problems collection
- Laboratory Practice: Transformers Tests.

## Specific objectives:
At the end of the topic the student will be able to know:
- What is the general principle of electromagnetic transformation.
- Understand the basic principle of operation of a transformer, its constitution and fundamental values.
- How differences exist between ideal and real single-phase transformer.
- How is the electrical equivalent circuit of the transformer and its physical meaning.
- What are the ratings or assigned and how to interpret.
- What is and what should the voltage drop in a transformer.
- What are the losses of the transformer, and how determined performance.
- What is a three-phase transformer.
- Understand the operation of three phase transformers and the most important features.
- How banks are made by connecting three-phase single-phase transformers.
- How are constituted the three columns transformers.
- How to connect the coils of three-phase transformer windings.
- The index schedule.
- Understand the working principle of special transformers: auto-transformers and instrument and protection transformers.
### Unit 6. Low voltage electrical installations.
**Protections. Measuring devices and electric rates and options**

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 37h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1. Introduction.</td>
<td>Laboratory classes: 7h 30m</td>
</tr>
<tr>
<td>6.2. Elements of an electrical installation.</td>
<td>Self study: 30h</td>
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<tr>
<td>6.3. Calculating power lines. Design criteria.</td>
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<tr>
<td>6.4. Low Voltage Electrotechnical Regulation (REBT).</td>
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<tr>
<td>6.5. Protection elements.</td>
<td></td>
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<tr>
<td>6.6. Ground wire.</td>
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<tr>
<td>6.7. Electricity meters.</td>
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<tr>
<td>6.8. Description of electric rates. Election of the rate.</td>
<td></td>
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<tr>
<td>6.9. Contract of power. Interpretation of electric bills.</td>
<td></td>
</tr>
</tbody>
</table>

**Related activities:**  
- Project of an electrical installation

**Specific objectives:**  
- At the end of the topic the student will be able to know and understand:
  - What are the elements of an electrical installation.
  - What are the design criteria and calculation of an electrical installation.
  - To know and apply the Low Voltage Electrotechnical Regulations.
  - What are the switching and protection of electrical installations.
  - What are the selection criteria of the switching and protection.
  - What is the ground wire.
  - Know what elements of measurement of electrical energy.
  - To identify the different electricity rates.
  - Knowing how to choose the best electricity rates.
  - How is a power contract.
  - How to interpret the electric bills.
Qualification system

The evaluation system consists of a continuous assessment by means of several tests, that detail to continuation, in order to approach it to a system of evaluation continued.

- Two written exams (controls)
- Practices will be qualified based on the attendance and the activities performed in the laboratory together with the preparation and delivery of practice reports.
- The final mark for the course is the obtained with the following tests and weights:
  - First written exam: 40%
  - Second written exam: 50%
  - Practical and efficient oral and written communication competence: 10%

- The course has a re-evaluation test

The students will be able to access the re-assessment test that meets the requirements set by the EEBE in its Assessment and Permanence Regulations (https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf)

Regulations for carrying out activities

There are no specific rules. Every study guide for each activity provides the actual dynamics.

Bibliography

Basic:


Complementary:


Others resources:

Hyperlink

Apunts de l’assignatura