Course guide
820016 - STE - Electrical Systems

Last modified: 08/08/2024

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

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

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

LECTURER

Coordinating lecturer: RODOLFO OSEIRA GOAS

Others: Primer quadrimestre:
HERMENEGILDO ALTELARREA SORIA - Grup: M21, Grup: M22, Grup: M23, Grup: M24, Grup: M31, Grup: M32, Grup: M33, Grup: M34, Grup: M41, Grup: M42, Grup: M43, Grup: M44
JAIME BUSTO ABADIA - Grup: T21, Grup: T22
SERGIO CORONAS HERRERO - Grup: T11, Grup: T12
JUAN CRUZ VAQUER - Grup: M21, Grup: M22, Grup: M23, Grup: M24
EDORTA LÓPEZ URZAINQUI - Grup: T13, Grup: T23
JUAN MORÓN ROMERA - Grup: M33, Grup: M34
RODOLFO OSEIRA GOAS - Grup: M43, Grup: M44, Grup: M51, Grup: M52, Grup: M53, Grup: M54, Grup: T11, Grup: T12, Grup: T13
JUAN ALBERTO PIZARRO RUIZ - Grup: M41, Grup: M42
JOSEP SEGARRA MULLERAT - Grup: M11, Grup: M12, Grup: M13, Grup: M14, Grup: T21, Grup: T22, Grup: T23

PRIOR SKILLS

Those from previous semesters.

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

Type	Hours	Percentage
Hours large group	45,0	30.00
Hours small group	15,0	10.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Unit 1. introduction

Description:
1.1. Systems, networks and electrical circuits.
1.2. Fundamental magnitudes: charge, current, voltage, power and energy. Unit systems.
1.3. Elements of an electrical circuit. Models. Voltage and current sources. Dependent and independent sources.
1.4. Continuous and discrete signals.

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?

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

Full-or-part-time: 3h 50m
Theory classes: 1h
Laboratory classes: 1h 30m
Self study : 1h 20m

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Unit 2. Resistive circuit analysis

Description:
2.1. The resistor. Current-voltage relationship. Ohm's law. Resistance and conductance. Joule's law. Power in a resistor.
2.2. Kirchhoff's laws. Current and voltage balancing in a circuit. Signs convention.
2.3. Voltage divider. Current divider.
2.4. Passive and active elements of a circuit.
2.5. Tellegen's theorem. Power balancing in a circuit. Signs convention.
2.6. General methods for circuit analysis. Mesh analysis. Nodal analysis.
2.7. Linearity. Superposition theorem.
2.8. Equivalent circuits.
2.9. Thévenin's and Norton's theorems.
2.10. Maximum power transfer theorem.

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 Thevenin's and Norton's theorems.
· To know and to apply the maximum power transfer theorem.

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

Full-or-part-time: 27h 40m
Theory classes: 11h
Laboratory classes: 2h
Self study : 14h 40m

Unit 3. Sinusoidal steady-state. Single-phase systems.

Description:
3. 1. Periodic signals, characteristic values: average and effective values, and form factor. Sinusoidal functions. Steady-state response.
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. 5. Phasor relationship for passive elements R, L and C. Response of basic elements in sinusoidal steady-state.
3. 6. Impedance and admittance. Impedance of series connected components. Admittance of parallel connected components. Equivalent circuits.
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.

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 (j w)? 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.

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

Full-or-part-time: 27h 40m
Theory classes: 11h
Laboratory classes: 2h
Self study : 14h 40m

Unit 4. Three-phase systems

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.
4.4. Analysis of three-phase networks with balanced and unbalanced loads.
4.5. Single phase loads connected to a three phase power.
4.6. Power in three-phase system.
4.7. Reactive power compensation in three phase balanced systems.
4.8. Three-phase voltages, currents, and power measurement.

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?

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

Full-or-part-time: 27h 40m
Theory classes: 11h
Laboratory classes: 2h
Self study : 14h 40m

Unit 5. Single-phase and Three-phase transformers

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.
5.10. Three-phase transformers. Three-phase banks of single-phase transformers.
5.11. Transformers three columns. Connection groups.
5.12. Special transformers: autotransformers and instrument and protection transformers.

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.
· What 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.

Related activities:
· Problems collection
· Laboratory Practice: Transformers Tests.

Full-or-part-time: 25h 40m
Theory classes: 11h
Self study : 14h 40m

Unit 6. Low voltage electrical installations. Protections. Measuring devices and electric rates options

Description:
6.1. Introduction.
6.2. Elements of an electrical installation.
6.3. Calculating power lines. Design criteria.
6.4. Low Voltage Electrotechnical Regulation (REBT).
6.5. Protection elements.
6.6. Ground wire.
6.7. Electricity meters.
6.8. Description of electric rates. Election of the rate.
6.9. Contract of power. Interpretation of electric bills.

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.

Related activities:
· Project of an electrical installation

Full-or-part-time: 37h 30m
Laboratory classes: 7h 30m
Self study : 30h

GRADING SYSTEM

Versión inglés:
The evaluation system consists of a continuous assessment by means of several tests, which are detailed next, in order to approach it to a system of continuous evaluation.
· 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 It 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 realization of all the laboratory sessions, tasks and assignments are mandatory. The non-realization of all the laboratory sessions, tasks, and assignments directly involve the non-evaluation of the subject.

- 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)

EXAMINATION RULES.

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

BIBLIOGRAPHY

Basic:

- Hayt, William H.; Kemmerly, Jack E.; Durbin, Steven M. Análisis de circuitos en ingeniería [on line]. 8ª ed. México D.F. [etc.]: McGraw Hill, cop. 2012 [Consultation: 29/04/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=5122. ISBN 9781456227739.
- Sanjurjo Navarro, Rafael; Lázaro Sánchez, Eduardo; Miguel Rodríguez, Pablo de. Teoría de circuitos eléctricos. Madrid [etc.]: McGraw-Hill, DL 1997. ISBN 8448111338.
- Fraile Mora, Jesús. Máquinas eléctricas. 8a ed. Madrid [etc.]: Ibergarceta, cop. 2016. ISBN 9788416228669.
- Jesús Fraile Mora. Circuitos eléctricos. 2ª ed. Madrid: Ibergarceta publicaciones, 2019. ISBN 9788416228478.

Complementary:

- Nahvi, Mahmood; Edminister, Joseph A. Circuitos eléctricos y electrónicos. 4ª ed. Madrid [etc.]: McGraw-Hill, cop. 2005. ISBN 8448145437.
- Moreno, Narciso; Bachiller, Alfonso; Bravo, Juan Carlos. Problemas resueltos de tecnología eléctrica. Madrid: International Thomson, cop. 2003. ISBN 8497321944.

RESOURCES

Hyperlink:

- Apunts de l'assignatura