Course guide
320019 - AC - Advanced Circuits

Last modified: 11/04/2025

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). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Jordi-Roger Riba

Others: Pedro Rodriguez
Andrés Tarrasó

PRIOR SKILLS

Students will be expected to have passed the subject Electrical Systems (third semester).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. ELE: Understanding of machine control, electric drive systems and their applications.

TEACHING METHODOLOGY

Face-to-face lecture sessions. In these sessions, the lecturer will explain concepts, guide students and set assignments.
- Applied face-to-face sessions. In these sessions, students will give presentations in groups of six on how they solved the problems in the set assignments. The students who are to give a presentation in a session will be chosen at random, although volunteers may come forward as a certain number of presentations must be given over the course.
- Directed study sessions in which the lecturer will monitor students' progress based on the set assignments.
- Independent learning. Students will be expected to use this time to learn concepts, complete the set assignments and prepare class work.
- Group work Students will be expected to work in pairs to prepare practical exercises and write reports.
They will also work on problems in groups of six whose solutions they will have to defend in the applied face-to-face sessions.

LEARNING OBJECTIVES OF THE SUBJECT

- Give basic training in and information about the specialisation.
- Acquire skills in calculus and the interpretation of results.
- Introduce techniques in the analysis and synthesis of circuits.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Self study	90,0	60.00
Hours small group	15,0	10.00

Type	Hours	Percentage
Hours medium group	15,0	10.00

Total learning time: 150 h

CONTENTS

TOPIC 1: MAGNETICALLY COUPLED CIRCUITS

Description:
1.1 Self-inductance
1.2 Mutual inductance
1.3 Coupling coefficient
1.4 Ideal transformers
1.5 Series coupled circuits
1.6 General circuits with coupling
1.7 Energy stored in coupled circuits

Specific objectives:
- Understand the concept of magnetic coupling
- Understand the principle of operation of transformers
- Resolution of magnetically coupled circuits

Related activities:
Work in group
First face-to-face test.

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Laboratory classes: 2h
Self study : 10h

TOPIC 2: THREE-PHASE SYSTEMS

Description:
2.1. Review of balanced three-phase systems
2.2. Unbalanced three-phase systems
2.2.1. Study of voltages and currents
2.2.2. Study of power
2.3. Improving the power factor

Specific objectives:
For students to:
- Learn the fundamental behaviour and characteristics of balanced three-phase systems.
- Calculate currents and voltages methodically in unbalanced three-phase systems.
- Calculate power budgets in unbalanced three-phase systems.
- Study the power factor in unbalanced systems.

Related activities:
Practical P1 - Measurements in unbalanced three-phased systems

Full-or-part-time: 30h
Theory classes: 6h
Practical classes: 2h
Laboratory classes: 4h
Self study : 18h

TOPIC 3: FREQUENCY RESPONSE

Description:
3.1. Analysis of variable frequency response
3.2. Half power frequency
3.3. Resonance
3.3.1. Series resonance
2.3.2. Parallel resonance
3.3.3. Other resonant circuits
3.4. Transfer function
3.5. Frequency response logarithmic plots
3.5.1. Bode diagrams

Specific objectives:
For students to:
- Understand the concept of impedance using variable frequency.
- Become familiar with electrical resonance.
- Understand the concept of the transfer function.
- Draw frequency response plots.

Related activities:
Practical P2 - Resonance
Practical P3 - Frequency response

Full-or-part-time: 30h
Theory classes: 6h
Practical classes: 3h
Laboratory classes: 3h
Self study : 18h

TOPIC 4: TRANSIENT ANALYSIS

Description:
4.1. Study of the transitory regime by the classical method
4.1.1. First order circuits
4.1.2. Second order circuits
4.2. Complex frequency concept
4.3. The Laplace transform method
4.3.1. Definition and properties
4.3.2. Important function transforms
4.3.3. Use of transformation tables
4.4. Application to linear network analysis
4.4.1. Circuit element models
4.4.2. Analysis Techniques

Related activities:
First class test
Practical P4 - Transient first- and second-order circuits

Full-or-part-time: 29h
Theory classes: 6h
Practical classes: 3h
Laboratory classes: 2h
Self study : 18h

TOPIC 5: APPLICATION OF FOURIER ANALYSIS IN ELECTRICAL SYSTEMS

Description:
5.1. Introduction. The permanent non-sinusoidal regime
5.2. Trigonometric forms of the Fourier series
5.3. Evaluation of Fourier coefficients
5.4. Filling factor and wave symmetry
5.5. Response to periodic excitation functions
5.6. Complex forms of the Fourier series
5.7. Fourier integral. Definition
5.8. Applications in electrical circuits
5.9. Power in non-sinusoidal regimes

Specific objectives:
For students to:
- Learn the characteristics and properties of Fourier analysis.
- Calculate voltages and currents in non-linear circuits.
- Calculate power in non-linear single-phase circuits
- Differentiate between power factor and cos(phi)

Related activities:
Practical P5 - Analysis and measurements in non-linear circuits

Full-or-part-time: 29h
Theory classes: 6h
Practical classes: 3h
Laboratory classes: 2h
Self study : 18h

TOPIC 6: MODELLING OF CIRCUITS - QUADRUPOLES

Description:
6.1. Definition of quadrupoles
6.2. Impedance and admittance parameters
6.3. Hybrid parameters
6.4. Transmission parameters
6.5. Association of quadrupoles
6.6. The relationship between parameters
6.7. Active quadrupoles

Specific objectives:
For students to:
- Know the relationship between input and output in a circuit.
- Understand the basic modelling techniques of electrical systems.
- Understand transformation modelling techniques.
- Understand interconnection modelling techniques.

Related activities:
Practical P6 - Determination of parameters in quadrupoles

Full-or-part-time: 14h
Theory classes: 2h
Practical classes: 2h
Laboratory classes: 2h
Self study : 8h

ACTIVITIES

PRACTICE P1. MEASURES SYSTEMS UNBALANCED THREE PHASE.

Description:
Unbalanced three phase circuits are simulated, the active and apparent power and power factor are measured. Finally the three phase circuits resulting from applying the
Stokvis Fortescue theorem are simulated and the results compared.

Specific objectives:
Studying the power factor in unbalanced systems.
Knowing and using symmetrical components decomposition

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

PRACTICE P2. RESONANCE

Description:
RLC series circuit is performed and the frequency that presents pure resistive behaviour is measured. The experiment was repeated but now with a parallel RLC circuit. Finally a mixed circuit is analysed.

Specific objectives:
Understand the concept of impedance with varying frequency.
Learn the phenomenon of electrical resonance.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

PRACTICE P3. FREQUENCY RESPONSE.

Description:
A circuit consisting of resistors, inductors and capacitors are fed with an alternating voltage variable frequency. After determining the starting point of the relationship between vought and Vin are measured. Then analyse its usefulness to pass some frequencies and attenuate others.

Specific objectives:
Understand the concept of transfer function.
Diagrams represent frequency response.
Learn about the different types of filter circuits.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

PRESENTIAL FIRST EXAM

Description:
The evaluations consist of individual tests and / or other assessment activities.

Specific objectives:
After each evaluation the student must have satisfactorily achieved the specific objectives detailed in the contents that have been part of assessments.

Material:
Enunciated of evidence and / or other material specified by the teacher.

Delivery:
The first assessment represents 35% of the final grade for the course.

Full-or-part-time: 3h
Theory classes: 3h

PRACTICE P4. TRANSIENT IN FIRST AND SECOND ORDER CIRCUITS

Description:
Sallen-Key circuit is made with adjustable gain and the transient response is measured for different values K. Moreover, the transfer function is calculated and determined its poles. Practice will conclude by comparing the measurements with the mathematical study.

Specific objectives:
Know the different types of possible responses.
Relate the transient response with the transfer function.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

PRACTICE P5. NONLINEAR CIRCUITS, ANALYSIS AND MEASURES

Description:
Nonlinear electrical circuit consisting of diodes and resistors are supplied with a sinusoidal signal, obtaining a response known Fourier analysis. Below is a PL filter is placed and measured the new answer. Finally justify analytically the amplitudes of the first three harmonics.

Specific objectives:
Experiment with electrical circuits in non- sinusoidal steady state.
Evaluate the Fourier coefficients.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 5h
Self study: 2h
Laboratory classes: 3h

PRACTICE P6. DETERMINE PARAMETERS IN QUADRIPOLES.

Description:
Will be based on a relatively complex electrical circuit and its parameters will be calculated quadripole equivalent. Both circuits are simulated and the results compared.

Specific objectives:
Relate the input and output response in a circuit.
Apply the basic techniques of modelling of electrical systems.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

PRACTICE P7. MEASURES. INTERPRETATION AND DATA PROCESS.

Description:
The accuracy of different measuring equipment shall be verified. Component parameters were measured and the usual electrical magnitudes are also measured.

Specific objectives:
Understand the characteristics of the instruments used.
Understand the basic measuring techniques.

Material:
Script of practice guidelines for the completion of the report and measuring equipment laboratory.

Delivery:
Throughout the session the report with the data obtained will be filled and responded reasonably to required issues. The note of the labs corresponding to 10% of the overall mark of subject.

Full-or-part-time: 4h
Self study: 2h
Laboratory classes: 2h

WORK IN GROUPS.

Description:
Students work in groups of 6 people, and made collections of problems that must be defended in class time.

Specific objectives:
Fix the knowledge developed in lectures.

Material:
Script work and guidelines for implementing the same.

Delivery:
After completing the course, each group must submit a dossier with all the problems solved. The evaluation of group work will count 15% of the final grade for the course.

Full-or-part-time: 24h
Self study: 24h

PRESENTIAL SECOND EXAM

Description:
The evaluations consist of individual tests and / or other assessment activities.

Specific objectives:
After each evaluation the student must have satisfactorily achieved the specific objectives detailed in the contents that have been part of assessments.

Material:
Enunciated of evidence and / or other material specified by the teacher.

Delivery:
The first assessment represents 40% of the final grade for the course.

Full-or-part-time: 3h
Theory classes: 3h

Theoretical lessons

Description:
Theoretical lessons of units 1 to 6

Material:
The class notes are provided in pdf format

Full-or-part-time: 56h
Self study: 32h
Theory classes: 24h

Problems solving

Description:
The exercicies corresponding to the units 1 to 6 will be solved during the sessions

Material:
The class notes with the solved exercices are provided in pdf format

Full-or-part-time: 35h
Self study: 20h
Practical classes: 15h

GRADING SYSTEM

- Total Exams: 70% (1st exam:35%, 2nd exam:35%)
- Workclass: 15%
- Laboratory: 15%

The unsatisfactory results of the 1st partial exam may be redirected by means of a exam to be carried out on the day fixed for the final exam. This test can be done at your discretion, all students enrolled. The grade will be between 0 and 10 and the grade obtained by application of the renewal will replace the initial grade of 1st partial exam, provided it is higher.
exam

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

EXAMINATION RULES.

The evaluations consist of the set of face-to-face evaluation acts and / or other evaluable activities that are part of the continuous evaluation. If any of the acts or activities is not carried out, it will be considered a zero.

BIBLIOGRAPHY

Basic:
- Fraile Mora, Jesús. Circuitos eléctricos. 2a ed. Madrid: Ibergarceta Publicaciones, 2019. ISBN 9788416228478.

Complementary:
- Irwin, J. David. Análisis básico de circuitos en ingeniería. 6a ed. México: Limusa Wiley, 2003. ISBN 9681862953.
- Conejo, Antonio J. [et al.]. Circuitos eléctricos para la ingeniería. Madrid [etc.]: Mc Graw Hill, 2004. ISBN 9788448141790.
- Carlson, A. Bruce. Teoría de circuitos: ingeniería, conceptos y análisis de circuitos eléctricos lineales. Madrid: International Thomson,

2002. ISBN 8497320662.
- Hayt, William H. [et al.]. Análisis de circuitos en ingeniería [on line]. 9a ed. México: McGraw-Hill, 2019 [Consultation: 08/03/2023]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=8725. ISBN 9781456272135.