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300217 - SL - Linear Systems

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 739 - TSC - Department of Signal Theory and Communications

Academic year: 2018

Degree: BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AIRPORT ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AIR NAVIGATION ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)

ECTS credits: 4,5 Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

Prior skills

·To have a fluent operation with Fourier Series and Transforms.
·To have a fluent operation with Laplace transforms

. Knowledge on the properties of electric parameters, such as the resistance, the capacitor and the coil
·Practice in using the basic measurement instrumental in an electronics laboratory: scope, function generator, power supply and multimeter. Knowledge of the basic electronic components and devices: protoboard, resistors, capacitors, and inductors.

Requirements

To have profitably attended the previous courses of:
·Àlgebra (Algebra)
·Fonaments de Física (Physics Fundamentals)
·Ampliació de Matemàtiques (Broadening on Maths)
·Càlcul (Calculus)

Degree competences to which the subject contributes

Specific:

1. CE 15 AERO. Conocimiento adecuado y aplicado a la Ingeniería de: Los principios de la mecánica del medio continuo y las técnicas de cálculo de su respuesta. (CIN/308/2009, BOE 18.2.2009)
2. CE 17 AERO. Conocimiento adecuado y aplicado a la ingeniería de: Los elementos fundamentales de los diversos tipos de aeronaves ; los elementos funcionales del sistema de navegación aérea y las instalaciones eléctricas y electrónicas asociadas; los fundamentos del diseño y construcción de aeropuertos y sus diversos elementos. (CIN/308/2009, BOE 18.2.2009)
3. CE 18 AERO. Conocimiento adecuado y aplicado a la Ingeniería de: Los fundamentos de la mecánica de fluidos; los principios básicos del control y la automatización del vuelo; las principales características y propiedades físicas y mecánicas de los materiales. (CIN/308/2009, BOE 18.2.2009)

Generical:

8. EFFICIENT USE OF EQUIPMENT AND INSTRUMENTS - Level 1: Using instruments, equipment and software from the laboratories of general or basic use. Realising experiments and proposed practices and analyzing obtained results.

Transversal:

4. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with

recommended information sources according to the guidelines set by lecturers.

5. 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 recommended information sources.
6. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
9. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

Teaching methodology

In the theoretical lectures (groups of 40 students), based on the professor exposition, the formal explanations are combined with a kind of continuous asking to the students in order to make easier the understanding of the course fundamentals. A good motivation for the study of new concepts and techniques is fundamental. So, they will be introduced from their need, avoiding as possible the study of subjects without a clear knowledge on their usefulness, which has to be rather perceived (a perception induced by the professor) than directly exposed.

In the lectures guided to get practice in exercises and problems (groups of 20 students), students can work, depending on each particular lecture, individually or in groups of up to 3 members. The objective is to solve problems already advanced in the theoretical lectures. The professor will solve (or will give guidelines to do that) together with the students the problems; and additional problems to be solved at home will be proposed. It is important that the professor will not destroy the start-up of the problems, which is the most educational part of the solution. Once started (or at least after elapsing a prudential time after the problem proposal), the professor will give the abovementioned guidelines. The capability to solve problems based on the pure retention (memory) is not an aspect to be boost.

In the Laboratory sessions (groups of 20 students), the students will work on couples. Each member of the couple has to make individually the previous study. The report is one for the couple, where the work made has to be presented and the interpreted results has to be related with the theoretical fundamentals previously seen in the theoretical lectures. Main conclusions are presented at the end of the delivered report.

Finally, in the Conducted Activities (groups of 20 students) some workshops will be arranged, where the student has to face the solution of selected problems, with little interference from the professor. The asking for help to the professor has to be preferably made over already started problems. Any help on the problem start-up is understood as a bee-line which may produce an honest and false feeling, from the student, to have learned the subject.

Finalmente en las sesiones de actividades dirigidas (grupos de 20 estudiantes como a máximo) se harán talleres donde el estudiante se enfrentará a la resolucióNn de problemas, con un grado de conductividad por parte del profesor que no entorpezca la autonomía del alumno, siendo preferible la ayuda sobre preguntas concretas de problemas ya empezados más que consultas generales sobre como enfocar soluciones, frecuentemente de respuestas obvias "a posteriori", lo que puede crear confusión al alumno sobre la dificultad real de los ejercicios y problemas, y que no debería descubrir a hora de los controles o exámenes.

Learning objectives of the subject

To describe and classify signals and systems, to find descriptive parameters (form and energy criteria), to operate with elemental signals and their combinations, and to operate with interconnected systems, simplifying structures and finding transfer functions.
· Regarding different technologies systems, to use the Laplace transform as a tool for obtaining models of linear circuitos and systems in the transformed domain, as well as their input-output relations.
· To obtain transient responses of systems and to classify them in function of their type and form, by using correctly the

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main descriptive parameters.
· To assess transient dynamics (kinds of responses, velocity and stability) from the p-z (pole-zero) diagram.
· To know the main characteristics of feedback systems, as well as their most usual characteristics.
· To assess the steady state response of linear systems. To draw the amplification and phase curves and to find the main parameters.
· To use the Fourier transform to find signal's spectra, which have to be correctly read and filtered.
· To know the types of linear filters, to assess them asymptotically from the p-z diagram, and to know basic applications.

Study load

Total learning time: 112h 30m	Hours large group:	26h	23.11%
	Hours medium group:	7h	6.22%
	Hours small group:	6h	5.33%
	Guided activities:	10h 30m	9.33%
	Self study:	63h	56.00%

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Content

Signals and Systems

Learning time: 25h 20m

Theory classes: 4h
Practical classes: 1h
Guided activities: 2h
Self study : 18h 20m

Description:
Course and faculty presentation. Revision of fundamental 'preliminary- aspects.
Signals and classification .
Basic types of signals and their properties .
Systems: types and properties. System's interconnection. Classification. Response of systems LTI.

Related activities:
Activity 1: Workshop of activities on signals and systems computations and representation.

Analysis of Linear Systems with Laplace transform

Learning time: 44h 50m

Theory classes: 10h
Practical classes: 4h
Laboratory classes: 4h
Guided activities: 4h 30m
Self study : 22h 20m

Description:
· Review of the Laplace Transform
· Dynamics of linear systems. Transfer functions. Kinds of responses. First and second order. Steady State analysis.
· Pole-zero diagrams. Stability. Canonic forms.
· Feedback systems
· Block algebra.
· Systems modeling.

Related activities:
· Activity 2: Workshop on transient responses computations and representation.
· Activity 3: Short examination on system's dynamics.
· Activity 4: Low-frequency lab: Experimentation on a 2nd order circuit.
· Activity 5: Computer laboratory:MATLAB, SIMULINK.
· Activity 6: Mid-term Exam

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Applications of Series and Fourier Transform	Learning time: 42h 20m Theory classes: 12h Practical classes: 2h Laboratory classes: 2h Guided activities: 4h Self study : 22h 20m

Description:
Review of the SS response. Amplification and phase curves, dB.
Review of Fourier Series and Transforms. Examples.
Signals and Systems: spectrum. Filters.
Asymptotic analysis
First and second order filters. Parameters. Main approximations (Butterworth, Tchebyschev, ...).
Introductory filtering examples.

Related activities:
Activity 7: Workshop on frequency response and filtering computations
Activity 8: Short examination on frequency response and filtering
Activity 9: Low-frequency lab. Experimentation of the frequency response of an active filter.
Activity 10: FINAL EXAMINATION

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Planning of activities

WORKSHOP OF ACTIVITIES ON SIGNALS AND SYSTEMS COMPUTATIONS AND REPRESENTATION

Hours: 10h
Guided activities: 2h
Self study: 8h

Description:
This activity is steered to make additional works or to assess students about the exercises and problems related with the classification and parameterization of signals.
The student may have a personalized guide to overcome the doubts and stoppers he has possibly found when trying to solve autonomously the proposed homework. In this way he can better prepare the short examination of activity 2.

Support materials:
The necessary support will be given by the professor along the sessions

Descriptions of the assignments due and their relation to the assessment:
Exercises of signals and systems

Specific objectives:
To learn how to classify, compute and make graphical representations of signals and systems

SHORT EXAMINATION ON SIGNALS & SYSTEMS AND CIRCUIT ANALYSIS IN THE LAPLACE DOMAIN

Hours: 1h
Practical classes: 1h

Description:
Examination based on the knowledge which should be already acquired from the proposed exercises

Descriptions of the assignments due and their relation to the assessment:
It has a weight of 15 % in the final qualification

Specific objectives:
At this point of the course, the student should be capable of:

· To classify Signals and Systems
· To compute and assess some characteristic values of a signal.
· To describe and operate with basic signals and their combinations
· To describe and assess the transient response, as well as the stability, by using the Laplace domain.

WORKSHOP ON TRANSIENT RESPONSES COMPUTATIONS AND REPRESENTATION

Hours: 11h
Guided activities: 3h
Self study: 8h

Description:
This activity is devoted to make additional works or to assess students about the exercises and problems related with the use of the Laplace transform to obtain transient responses.
The student may have a personalized guide to overcome the doubts and stoppers he has possibly found when trying to solve autonomously the proposed homework. In this way he can better prepare the next examination.

Support materials:
The necessary support will be given by the professor along the sessions

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Descriptions of the assignments due and their relation to the assessment:
Proposed exercises and works

Specific objectives:
To get operability in the topics described as specific objectives in activity 4.

LOW-FREQUENCY LAB: EXPERIMENTATION ON A 2ND ORDER CIRCUIT	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Organized as a 2h session. Students will work in couples.
The laboratory work is the study of different transient responses of a Sallen-Key filter. The Operational Amplifier will be roughly introduced, just for the practice needs.

Support materials:
Laboratory stuff

Descriptions of the assignments due and their relation to the assessment:
It is mandatory the attendance of this practice. The qualification will be set according to:
Practice realization
Previous studies of the practice
Reports
It has a weight of 5 % in the final qualification

Specific objectives:
After the practice, the student has to be capable of:
- To measure transient signals
- To relate the transient responses with the p-z diagram
- To understand some electronic oscillator concepts.

COMPUTER LABORATORY: SIMULINK. SIMULATION OF A D.C. MOTOR	Hours: 6h Laboratory classes: 2h Self study: 4h

Description:
Arranged as a 2h session. Students will labor in couples.
The laboratory work will be the identification (parametric) of a d.c motor from the step response, its modeling and the qualitative assessment of some feedback effects on the transient response.

Support materials:
Matlab/Simulink

Descriptions of the assignments due and their relation to the assessment:
It is mandatory the attendance of this practice. The qualification will be set according to:
Practice realization
Previous studies of the practice
Reports
It has a weight of 5% in the final qualification

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Specific objectives:
After the practice, the student has to be able to:
- Make element identification of first and second order systems
- Model (basically) a dc motor
- Describe the effects of some basic feedback strategies.
- Use the Matlab/Simulink software

MID-TERM EXAM	Hours: 1h 30m Guided activities: 1h 30m

Description:
Exam (22,5% in the final grade)

WORKSHOP ON FREQUENCY RESPONSE AND FILTERING COMPUTATIONS	Hours: 9h Guided activities: 2h 30m Self study: 6h 30m

Description:
This activity is devoted to make additional works or to assess students about the exercises and problems related with the signals spectra (Fourier) and the filtering process.
The student may have a personalized guide to overcome the doubts and stoppers he has possibly found when trying to solve autonomously the proposed homework. In this way he can better prepare the next examination.

Support materials:
The necessary support will be given by the professor along the sessions.

Descriptions of the assignments due and their relation to the assessment:
Proposed exercises and works.

Specific objectives:
To achieve operability in the topics described as specific objectives in activity 8.

SHORT EXAMINATION ON MODELLING AND CONTROL / SHORT EXAMINATION ON FREQUENCY RESPONSE AND FILTERING	Hours: 1h Practical classes: 1h

Description:
Examination based on the knowledge which should be already acquired from the proposed exercises

Descriptions of the assignments due and their relation to the assessment:
It has a weight of 15% in the final qualification

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Specific objectives:

This SHORT EXAMINATION will be focused on the part of CONTROL + MODELLING or on the part of FREQUENCY RESPONSE + FILTERING. Never both parts simultaneously.

At this point of the course, the student should be capable of:

A) OPTION CONTROL * MODELLING:

· To obtain and to simplify block diagrams of mechanical systems (translation, rotation or torsion)

- To obtain and to operate with transfer functions.

· To know application examples.

B) OPTION FREQUENCY RESPONSE + FILTERING:

· To obtain signals spectra and to establish relationships between spectra and filter responses

· To classify filters and to compute basic describing parameters. .

· To asymptotically assess the filter response from the transfer function and from the p-z diagram.

· To know filter application examples.

LOW-FREQUENCY LAB. EXPERIMENTATION OF THE FREQUENCY RESPONSE OF AN ACTIVE FILTER

Hours: 4h 30m
Laboratory classes: 2h
Self study: 2h 30m

Description:

Set up as a 2h session. Students will work in couples.
The laboratory work is the study of the frequency response of a pass-band filter. Besides the relationship between transient and frequency responses is also studied.

Descriptions of the assignments due and their relation to the assessment:

It is mandatory the attendance of this practice. The qualification will be set according to:
Practice realization
Previous studies of the practice
Reports
It has a weight of 5 % in the final qualification

Specific objectives:

After the practice, the student has to be able to:
- Measure and characterize a filter
- Explain the filter effects on the incoming signals.

FINAL EXAM

Hours: 1h 30m
Guided activities: 1h 30m

Description:

Final Exam (32.5%of the final grade)

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Qualification system

· 55 % Examinations. One at half-quarter (22.5%) and a final examination at the end of the quarter (32.5%).
· 30 % short-examinations: Two, 15% each.
· 15 % among memories and Laboratory reports, partially checked as questions in the examinations.

Regulations for carrying out activities

In Laboratory activities the attendance is mandatory. It is also mandatory the realization of the previous studies and the deliverance of the practice memories, reports or articles. What is most valuable in the memories is the good undestanding of results, rather than the bare description.
The grade from the laboratory will be correlated with theoretical questions on the short or long examinations, with a weigth of 70% from the memories + lab work and 30% from the questions.

Bibliography

Basic:

Ogata, Katsuhiko; Dormido Canto, Sebastián; Dormido Canto, Raquel. Ingeniería de control moderna. 5ª ed. Madrid: Pearson Educación, 2010. ISBN 9788483226605.

Oppenheim, Alan V.; Willsky, Alan S. Señales y sistemas. 2ª ed. México [etc.]: Prentice-Hall Hispanoamericana, 1997. ISBN 970170116X.

Thomas, Roland E.; Rosa, Albert J.; Toussaint, Gregory J. The Analysis and design of linear circuits. 6th ed. Hoboken, NJ [etc.]: John Wiley & Sons, 2009. ISBN 9780470383308.

Complementary:

Lathi, B.P. Signal processing and linear systems. International ed. New York: Oxford University Press, 2010. ISBN 9780195392579.

Hostetter, Gene H.; Savant, Clement J.; Stefani, Raymond T. Sistemas de control. México: McGraw-Hill, 1990. ISBN 968422592X.

Taylor, Fred J. Principles of signals and systems. New York: McGraw-Hill, 1994. ISBN 0079111718.

Phillips, Charles L.; Parr, John M. Signals, systems, and transforms. 2nd ed. Upper Saddle River: Prentice- Hall, 1999. ISBN 0130953329.

Oppenheim, Alan V.; Willsky, Alan S. Señales y sistemas. 2ª ed. México [etc.]: Prentice-Hall Hispanoamericana, 1997. ISBN 970170116X.

Bertran Albertí, Eduard; Montoro López, Gabriel. Circuitos y sistemas lineales : curso de laboratorio [on line]. Barcelona: Edicions UPC, 2000Available on: <http://hdl.handle.net/2099.3/36416>. ISBN 848301372X.

Lathi, B. P. (Bhagwandas Pannalal). Introducción a la teoría y sistemas de comunicación. México, [etc.]: Limusa : Noriega, 1974. ISBN 9681805550.

Others resources: