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: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (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:
- Álgebra (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 principales características y propiedades físicas y mecánicas de los materiales. (CIN/308/2009, BOE 18.2.2009)

General:
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...
300217 - SL - Linear Systems

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 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.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>26h</th>
<th>23.11%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time: 112h 30m</td>
<td>Hours medium group:</td>
<td>7h</td>
<td>6.22%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>6h</td>
<td>5.33%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>10h 30m</td>
<td>9.33%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>63h</td>
<td>56.00%</td>
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</table>
### Signals and Systems

**Description:**
Course and faculty presentation. Revision of fundamental 'preliminary' aspects.
Signals and classification.
Basic types of signals and their properties.

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

### Analysis of Linear Systems with Laplace transform

**Description:**
- Review of the Laplace Transform
- 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
### Applications of Series and Fourier Transform

<table>
<thead>
<tr>
<th>Learning time: 42h 20m</th>
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<tbody>
<tr>
<td>Theory classes: 12h</td>
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<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 4h</td>
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<tr>
<td>Self study : 22h 20m</td>
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</tbody>
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#### Description:
- Review of the SS response. Amplification and phase curves, dB.
- 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
### Planning of activities

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Hours</th>
<th>Support materials</th>
<th>Description</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WORKSHOP OF ACTIVITIES ON SIGNALS AND SYSTEMS COMPUTATIONS AND REPRESENTATION</strong></td>
<td>10h</td>
<td>Guided activities: 2h, Self study: 8h</td>
<td>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.</td>
<td>To learn how to classify, compute and make graphical representations of signals and systems</td>
</tr>
<tr>
<td><strong>SHORT EXAMINATION ON SIGNALS &amp; SYSTEMS AND CIRCUIT ANALYSIS IN THE LAPLACE DOMAIN</strong></td>
<td>1h</td>
<td>Practical classes: 1h</td>
<td>Examination based on the knowledge which should be already acquired from the proposed exercises</td>
<td>Examine the knowledge acquired in the course</td>
</tr>
<tr>
<td><strong>WORKSHOP ON TRANSIENT RESPONSES COMPUTATIONS AND REPRESENTATION</strong></td>
<td>11h</td>
<td>Guided activities: 3h, Self study: 8h</td>
<td>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.</td>
<td>Describe and assess the transient response, as well as the stability, by using the Laplace domain</td>
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</table>

**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 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
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

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

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
## 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

<table>
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<tr>
<th>Hours</th>
<th>Description</th>
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<tbody>
<tr>
<td>1h 30m</td>
<td>Exam (22.5% in the final grade)</td>
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### WORKSHOP ON FREQUENCY RESPONSE AND FILTERING COMPUTATIONS

<table>
<thead>
<tr>
<th>Hours</th>
<th>Description</th>
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<tbody>
<tr>
<td>9h</td>
<td>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.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Support materials:</th>
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<tbody>
<tr>
<td>The necessary support will be given by the professor along the sessions.</td>
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<table>
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<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
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<tbody>
<tr>
<td>Proposed exercises and works.</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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<tbody>
<tr>
<td>To achieve operability in the topics described as specific objectives in activity 8.</td>
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### SHORT EXAMINATION ON MODELLING AND CONTROL/ SHORT EXAMINATION ON FREQUENCY RESPONSE AND FILTERING

<table>
<thead>
<tr>
<th>Hours</th>
<th>Description</th>
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<tbody>
<tr>
<td>1h</td>
<td>Examination based on the knowledge which should be already acquired from the proposed exercises</td>
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<table>
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<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
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<tr>
<td>It has a weight of 15% in the final qualification</td>
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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

| 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

| Description: |
| Final Exam (32.5% of the final grade) |

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

| Hours: |
| 1h 30m |
| Guided activities: 1h 30m |
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 understanding 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 weight of 70% from the memories + lab work and 30% from the questions.

Bibliography

Basic:

Complementary:

Others resources: