Universitat de Lleida

DEGREE CURRICULUM

BASICS OF THE CONTROL THEORY

Coordination: PALLEJÀ CABRÉ, TOMÀS

Academic year 2021-22

BASICS OF THE CONTROL THEORY 2021-22

Subject's general information

<table>
<tr><td>Subject name</td><td>BASICS OF THE CONTROL THEORY</td></tr>
<tr><td>Code</td><td>102124</td></tr>
<tr><td>Semester</td><td>1st Q(SEMESTER) CONTINUED EVALUATION</td></tr>
<tr><td>Typology</td><td><table><tr><th>Degree</th><th>Course</th><th>Character</th><th>Modality</th></tr><tr><td>Bachelor's Degree in Automation and Industrial Electronic Engineering</td><td>3</td><td>COMPULSORY</td><td>Attendance-based</td></tr></table></td></tr>
<tr><td>Course number of credits (ECTS)</td><td>6</td></tr>
<tr><td>Type of activity, credits, and groups</td><td><table><tr><th>Activity type</th><td>PRALAB</td><td>PRAULA</td><td>TEORIA</td></tr><tr><th>Number of credits</th><td>0.8</td><td>2.2</td><td>3</td></tr><tr><th>Number of groups</th><td>2</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td>Coordination</td><td>PALLEJÀ CABRÉ, TOMÀS</td></tr>
<tr><td>Department</td><td>COMPUTER SCIENCE AND INDUSTRIAL ENGINEERING</td></tr>
<tr><td>Teaching load distribution between lectures and independent student work</td><td>(40%) 60 h classroom
(60%) 90 h autonomous work</td></tr>
<tr><td>Important information on data processing</td><td>Consult this link for more information.</td></tr>
<tr><td>Language</td><td>Idioma Percentatge d'ús
Anglès 10.0
Castellà 10.0
Català 80.0</td></tr>
</table>

BASICS OF THE CONTROL THEORY 2021-22

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
PALLEJÀ CABRÉ, TOMÀS	tomas.palleja@udl.cat	6,8	

Subject's extra information

Because to the current pandemic situation, the 20/21 academic year has been planned in a 50% in-person classes, 50% on-line classes and in-person exams. Due to the virus nature, it might be significant outbreaks that limit the people's mobility (throughout the whole territory or in specific areas). For this reason, the 20/21 academic year planning and teaching methodology is susceptible to modifications conditioned by the pandemic evolution.

For a proper development of the teaching, is needed that the student has already reach the basic knowledge of general topics like differential equations, Laplace’s Transforms and previous knowledge in Dynamics, Circuit’s Theories and Electronics In order to reach the evaluations in a satisfactory level is recommended to be present at the lecture sessions and to have an active participation in them. Apart, is recommended that the student solves by its own the proposed exercises and the regular crosscheck of the bibliography.

The subject is defined to form specialists in Automation; it develops the theoretical basic knowledge in terms of Automation Controls that will be used as a basis for the learning of other graduation subjects and the future professional exercise. The study of the subject implies that the student is getting the basic needed knowledge to understand, analyze, design and evaluate Automation Control Systems. For that, is necessary to introduce to the student the Linear Control systems by the classic analysis techniques and system designs in the time-domain and frequency-domain performances.

Learning objectives

- Modelling electrical and mechanical systems using differential equations
- Linearization of nonlinear mathematical models
- Transform lineal differential equation to: block diagrams, transfer functions and state space models
- Transient and Steady-State Response Analyses.
- Analyze and design control systems using: root-locus and frequency method
- Analyze control systems using state space models
- Analyze and design PID controls.

Competences

Cross-disciplinary competences

- **EPS1.** Capacity to solve problems and prepare and defense arguments inside the area of studies.
- **EPS2**. Capacity to gather and interpret relevant data, within the area of study, to judge and think about relevant subjects of social, scientific and ethical nature.

Specific competences

- **GEEIA25.** Knowledge and capacity for modelling and simulation of systems.
- **GEEIA26.** Knowledge of automation and technical regulation of control and his application to the industrial automation.
- **GEEIA27.** Knowledge of principles and applications of robotic systems.
- **GEEIA29.** Capacity to design systems of industrial automation control.

Subject contents

1. Introduction to Control Systems

1-1. Introduction

1-2. Examples of Control Systems

1-3. Closed-Loop Control Versus Open-Loop Control

1-4. Design and Compensation of Control Systems

2. Mathematical Modeling of Control Systems

2-1. Introduction

2-2. Transfer Function and Impulse-Response Function

2-3. Automatic Control Systems

2-4. Modeling in State Space

2-5. State-Space Representation of Scalar Differential Equation Systems

2-6. Transformation of Mathematical Models with MATLAB

2-7. Linearization of Nonlinear Mathematical Models

3. Mathematical Modeling of Mechanical Systems and Electrical Systems

3-1 Mathematical Modeling of Mechanical Systems

3-2 Mathematical Modeling of Electrical Systems

4. Mathematical Modeling of Fluid Systems and Thermal Systems

4-1 Introduction

5. Transient and Steady-State Response Analyses

5-1 First-Order Systems

5-2 Second-Order Systems

5-3 Higher-Order Systems

5-4 Transient-Response Analysis with MATLAB

5-5 Routh’s Stability Criterion

5-6 Effects of Integral and Derivative Control Actions on System Performance

5-7 Steady-State Errors in Unity-Feedback Control Systems

6 Control Systems Analysis and Design by the Root-Locus Method

6-1 Root-Locus Plots

6-2 Plotting Root Loci with MATLAB

6-3 Root-Locus Plots of Positive Feedback Systems

6-4 Root-Locus Approach to Control-Systems Design

6-5 Lead Compensation

6-6 Lag Compensation

6-7 Lag–Lead Compensation

6-8 Parallel Compensation

7 Control Systems Analysis and Design by the Frequency-Response Method

7-1 Bode Diagrams

7-2 Polar Plots

7-3 Log-Magnitude-versus-Phase Plots

7-4 Nyquist Stability Criterion

7-5 Stability Analysis

7-6 Relative Stability Analysis

7-7 Closed-Loop Frequency Response of Unity-Feedback Systems

7-8 Experimental Determination of Transfer Functions

7-9 Control Systems Design by Frequency-Response Approach

7-10 Lead Compensation

7-11 Lag Compensation

7-12 Lag–Lead Compensation

8. PID Controllers and Modified PID Controllers

8-1 Ziegler–Nichols Rules for Tuning PID Controllers

9 Control Systems Analysis in State Space

9-1 State-Space Representations of Transfer-Function Systems

9-2 Transformation of System Models with MATLAB

9-3 Solving the Time-Invariant State Equation

9-4 Some Useful Results in Vector-Matrix Analysis

9-5 Controllability

9-6 Observability

Methodology

Master class

Problem-based learning

Practices using MatLab

Development plan

Week	Description	Classroom Activity	Classroom/independent work
1	Lecture and problems	Lesson 1	4h/3h
2-3	Lecture and problems	Lesson 2	8h/8h
4-5	Lecture and problems	Lesson 3	8h/8h
5-6	Lecture and problems	Lesson 4	8h/10h
7	Práctiquas con ordenador	Lesson 1-4	4h/12h
8	**Written tests**	Lesson 1-4	
9-11	Lecture and problems	Lesson 5	12h/12h
12-14	Lecture and problems	Lesson 6	12h/12h
15	Práctiquas con ordenador	Lesson 5-6	4/25h
17	**Written tests**	Lesson 1-6	
20	**Written tests (Recovery)**	Lesson 1-6	

Evaluation

Due to the class incremental learning, the second partial exam will have a greater deal than the first one. To avoid students relaxing at the end of the course, a mark higher than 3.5 will be expected at the second partial in order to average it with the practices, that is to say, the final mark will be like so:

First Partial Mark:	***PP***	First Assignment:	***P1***
Second Partial Mark:	***SP***	Second Assignment	***P2***
Recovery Exam	***RE***	Continuous evaluation	***AC***

Case	Tests marks	Fiinal mark calculation
A	Si (***PP*** ≥ 5 i ***SP*** < 3.5)	***PP*** *0.3* + ***SP*** *0.4*
B	Si (***PP*** ≥ 5 i ***SP*** ≥ 3.5)	***PP*** 0.25 + ***SP*** 0.40 + ***AC*** 0.10 + ***P1*** 0.10 + ***P2*** 0.15
C	Si (***PP*** < 5 i ***SP*** ≥ 3.5)	***SP*** 0.65 + ***AC*** 0.10 + ***P1*** 0.10 + ***P2*** 0.15
D	Si (***PP*** < 5 i ***SP*** < 3.5)	***SP*** 0.65

E	Si (***RE*** ≥ 3.5)	***AC*** 0.10 + ***P1*** 0.10 + ***P2*** 0.15 + ***ER*** 0.65
F	Si (***RE*** < 3.5)	***ER*** 0.65
For the case B, final marck = max{B,C}		

Bibliography

Recommended bibliography

Control Systems, Katsuhiko Ogata.

Automatic Control Systems, Benjamin Kuo.

Sistemas de Control, Hostetter