Course guide
240754 - 240754 - Digital Control

Last modified: 10/04/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGIES AND ECONOMIC ANALYSIS (Syllabus 2018). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: Carlos Augusto Ocampo Martínez

Others: Ocampo Martinez, Carlos Augusto
Serna Higuita, Leidy Yanet

PRIOR SKILLS

Students are supposed to have basic knowledge of system dynamics, simple modeling of dynamic systems, concepts of proportional-integral-derivative controllers, and definitions of frequency response. Additionally, knowledge of linear algebra and differential equations is also required.

REQUIREMENTS

System dynamics, differential equations, linear algebra

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEGTI10. (ENG) Coneixements d'automàtica industrial i mètodes i sistemes de control.
CEGTI 1. (ENG) Capacitat per la resolució dels problemes matemàtics que poden plantejar-se en l'enginyeria. Aptitud per aplicar els coneixements sobre: àlgebra lineal; geometria; geometria diferencial; càlcul diferencial i integral; equacions diferencials i en derivades parcials; mètodes numèrics; algorítmica numèrica; estadística i optimització.

Transversal:
CT5. (ENG) ÚS SOLVENT DELS RECURSOS D'INFORMACIÓ: Gestionar l'adquisició, l'estructuració, l'anàlisi i la visualització de dades i informacions en l'àmbit d'especialitat i valorar de forma crítica els resultats d'aquesta gestió.

TEACHING METHODOLOGY

The methodology used includes the master lesson for the suitable establishment of the conceptual background of the subject and to adequately understand its use and interrelation with other concepts related to the area of knowledge. In addition, problem sessions and Lab activities will be held in order to reinforce definitions and application of subject concepts in academic (synthetic) and real cases. These applications will allow the students to understand the role of the subject as a source of useful knowledge to solve everyday problems.

In the middle of the course, a mid-term evaluation is carried out mainly on theoretical topics, which consists of questions of a conceptual nature or that require basically qualitative reasoning. Finally, an evaluation exam of the skills and abilities acquired throughout the course is carried out at the end of the learning process. Lab activities aim to deal with a more applied problem and with numerical resolution using tools such as Matlab, Maple and Simulink.

LEARNING OBJECTIVES OF THE SUBJECT

Main objective
At the end of the course, the student must be able to analyze and design digital control systems and must have sufficient basis for further study of advanced control methods.

Specific objectives
- Provide with the basic knowledge about the mathematical modeling of discrete-time dynamic systems and about the methods of analyzing their behavior.
- Introduce digital control by studying the main methods of analysis and synthesis of control systems using modern electronic devices.
- Show the possibilities and limitations of electronic devices when implementing discrete-time automatic control approaches in real case studies.

STUDY LOAD

Type	Hours	Percentage
Hours small group	9,0	8.00
Self study	67,5	60.00
Hours large group	36,0	32.00

Total learning time: 112.5 h

CONTENTS

Introduction and motivation

Description:
- Presentation of the subject
- Revisit previous concepts
- Description of the role of digital control in society
- Architectures

Specific objectives:
In this section, the basic concepts of the subject are introduced from a qualitative point of view, its importance is described, and previous concepts that are key to monitoring the proposed content are recalled.

Full-or-part-time: 5h 30m
Theory classes: 3h
Self study : 2h 30m

Signal sampling and discretization

Description:
- Sampling and holding
- A / D and D / A conversion
- Mathematical study of sampling
- Sampling theorem
- Reconstruction of sampled signals

Specific objectives:
This section deals with the characterization of discrete signals, their obtaining from continuous signals and the different signal treatments that must be taken into account within a discrete-time control loop. Additionally, the mathematical formalism of the sampling and its consequences on the sampled signals are established.

Full-or-part-time: 16h
Theory classes: 6h
Self study : 10h

Discrete-time dynamic systems

Description:
- Representation of dynamic systems in discrete time
- Definition and properties of the z-transform
- Transfer function in z
- Discrete-time state-space realizations
- Relationship between transfer function and realizations in state space
- Discretization of continuous-time systems

Specific objectives:
This section introduces the mathematical tools for the representation and analysis of dynamic systems in discrete time.

Full-or-part-time: 24h
Theory classes: 6h
Laboratory classes: 3h
Self study : 15h

Time-domain analysis

Description:
- Temporal response of discrete-time systems
- Stability analysis
- Accuracy. Stationary error and types
- Comparison of responses of systems in continuous and discrete times

Specific objectives:
This section analyzes the most relevant features and characteristics of discrete-time systems in the temporal domain. The output response of such systems and its representative parameters are studied. The concept of stability is introduced according to the modeling approach considered. Finally, the most important differences in the responses of a system are highlighted, depending on whether it is modeled and simulated in either continuous or discrete time.

Full-or-part-time: 26h
Theory classes: 8h
Laboratory classes: 3h
Self study : 15h

Design of digital controllers

Description:
Digital controllers and control algorithms
Digital PID controllers
General-structure and PID controllers
Pole assignment and other specifications
Algebraic design of digital controllers
Digital control design using state-space methods

Specific objectives:
This section introduces the design of discrete-time control strategies for linear systems. The criteria for the use of each of the strategies introduced are established and their advantages and disadvantages are highlighted.

Full-or-part-time: 28h
Theory classes: 9h
Laboratory classes: 3h
Self study : 16h

Application examples

Description:
Exercises and application problems of automatic control in discrete time within various areas of engineering and economics.

Full-or-part-time: 13h
Theory classes: 4h
Self study : 9h

GRADING SYSTEM

The grading system consists of three types of assessment tests:
- Mid-term evaluation test of theoretical concepts and definitions, based on conceptual questions or that require qualitative reasoning. The grade of this section is Gmt.
- Lab activities exam, covering all the topics discussed during the sessions as well as proposed exercises within the support material provided. The grade of this section is Glab.
- Final exam, consisting of problems over the whole program of the subject. The grade of this exam is Gfe.

The final grade under regular call (Gtot) is calculated as follows:
Gtot_reg = 0.3 Gmt + 0.2 Glab + 0.5 Gfe

Reassessment
It consists in a final-exam-type evaluation covering the whole subject contents. The grade of this exam is Gra. The final grade under extraordinary call (Gtot_rv), taking into account the reassessment, is calculated as follows:
Gtot_rv = 0.2 Glab + 0.8 Gra
The maximum possible grade in the reassessment call will be 5.0. Then,
Gtot_rv = min((0.2 Glab + 0.8 Gra), 5.0)
Finally, the final subject's grade will be
Gtot = max(Gtot_reg,Gtot_rv)

EXAMINATION RULES.

- The development of the Lab sessions is a necessary condition to be evaluated of the subject.
- The Lab activities can only be retireved if it has not been possible to carry them out on the dates initially provided for duly justified reasons. For the corresponding retrievement, students should contact the teacher responsible for these activities as soon as possible and always before the end of the academic period.

BIBLIOGRAPHY

Basic:
- Åström, Karl J; Wittenmark, Björn. Computer-controlled systems : theory and design [on line]. 3rd ed. Mineola, NY: Dover publications, cop. 2011 [Consultation: 29/03/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1893090. ISBN 9780486486130.
- Kuo, Benjamin C. Digital control systems. 2nd ed. New York ; Oxford: Oxford University Press, cop. 1992. ISBN 0195120647.

Complementary:
- Malekpour, S.; Primbs, J. A. and Barmish, B. R.. "On Stock Trading Using a PI Controller in an Idealized Market: The Robust Positive Expectation Property". Proceedings of the IEEE Conference on Decision and Control [on line]. pp. 1210-1216 [Consultation: 14/09/2020]. Available on: https://ieeexplore-ieee-org.recursos.biblioteca.upc.edu/document/6760047.- Baillieul, John; Samad, Tariq. Encyclopedia of Systems and Control [on line]. London: Springer London, 2019 [Consultation: 30/03/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/referencework/10.1007/978-3-030-44184-5. ISBN 9781447151029.