Course guide
240EQ013 - 240EQ013 - Process Control

Last modified: 27/05/2024

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

Degree: **Academic year:** 2024 **ECTS Credits:** 4.5
Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: JORDI SOLÀ SOLER

Others: ABEL TORRES CEBRIÁN

PRIOR SKILLS

Basic mathematical knowledge (linear algebra, elementary calculus, complex variable and linear differential equations) and basic control knowledge.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Apply knowledge of mathematics, physics, chemistry, biology and other natural sciences, obtained through study, experience, and practice, critical reasoning to establish economically viable solutions to technical problems.

2. Conceptualize engineering models; apply innovative methods in problem solving and applications suitable for the design, simulation, optimization and control of processes and systems.
3. Ability to solve problems that are unfamiliar, incompletely defined, and have competing specifications, considering the possible methods of solution, including the most innovative, selecting the most appropriate, and to correct implementation, evaluating the different solutions Design.

Generical:
4. Ability to apply the scientific method and the principles of engineering and economics, to formulate and solve complex problems in processes, equipment, facilities and services, in which the material changes its composition, state or energy content, characteristic of chemical industry and other related sectors which include the pharmaceutical, biotechnology, materials, energy, food or environmental.
5. Conceive, design, calculate, and design processes, equipment, manufacturing and service facilities in the field of chemical engineering and related industrial sectors in terms of quality, safety, economy, rational and efficient use of natural resources and conservation environment.
6. Possess independent learning skills to maintain and enhance the competencies of chemical engineering to enable the continued development of their profession.
7. Know how to establish and develop mathematical models using appropriate informatics, scientific and technological basis for the design of new products, processes, systems and services, and for other already developed optimization.
8. Ability to analyze and synthesize to the continued progress of products, processes, systems and services using criteria of safety, affordability, quality and environmental management.

Transversal:
9. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

TEACHING METHODOLOGY

Subject in process of extinction. There is no teaching, the students that enroll it do so only with the right to an exam.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of the course is to progress in the knowledge of control systems analysis and design tecniques and in the fundamental aspects required for the implementation of these control systems to the chemical processes.
The specific objectives are:
·To settle the bases of basic theory for continuous time linear systems dynamics through the study of the main tools for the abalysis and design of these kind of systems
·To introduce the basic control structures in closed loop and in open loop
·To present the state space representation as a different way to model the dynamic systems which introduces new tools for the analysis and the design of the controllers
·To generalise the transfer function concept to systems with multiple inputs and multiple outputs and introduce tools for the analysis and design of this kind of systems
· To present the digital control as the necessary formulation to implement computer based controllers
· To study the z transform, its properties and its use in the analysis and design of computer based control systems
· To introduce advanced control techniques used in the chemical industry
· To study the main actuators and sensors found in the chemical processes as well as the technological chain that includes data adquisition, data processing, generation of the control actions and actuation.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	24.00
Self study	72,0	64.00
Hours small group	13,5	12.00

Total learning time: 112.5 h

CONTENTS

-Basic theory of the control of linear systems

Description:
Overview of the basic theory of control of the linear systems in continous-time (analog) with external representation. Presentation of examples and problems in the field of chemical processes.

Specific objectives:
- Modelization of the systems with external representation (transfer function, block diagram)
- Time response of the first and second degree systems (stability, dynamic characteristics)
- Feedback control, (PID design, cascade connection)
- Analysis in the frecuency domain

Related activities:
Two practical sessions in the lab dedicated to the design, analysis and simulation of controllers

Full-or-part-time: 30h
Theory classes: 8h
Laboratory classes: 4h
Self study : 18h

-Internal representation

Description:
Present the intern representation with a different formulation to the external representation from which new tools derive for the analysis of the linear systems and a whole family of techniques for the design of controllers

Specific objectives:
- Definition of state space
- Equivalences and differences between internal and external representations
- Solution of the state equation
- Reachability and observability
- Design of controllers by pole placement
- Design of observers

Related activities:
A practical session devoted to the use of MATLAB for the analysis and design of controllers by internal representation

Full-or-part-time: 15h
Theory classes: 4h
Laboratory classes: 2h
Self study : 9h

Introduction to digital (discrete-time) control

Description:
Basic knowledge about mathematical modelling of dynamic systems in discrete time and about study methods of its performance. Introduction to Digital Control by the study of the main analysis and synthesis methods of computer control systems

Specific objectives:
- Architecture of a digital control system
- Sampling and digitalisation of signals
- Transfer function in z
- Analysis in the time domain
- Design of digital controllers

Related activities:
A practical session devoted to the use of MATLAB for digital controller design

Full-or-part-time: 21h
Theory classes: 6h
Laboratory classes: 2h
Self study : 13h

-Advanced controllers

Description:
Overview about the different techniques of advanced control and assessment of their suitability in different types of chemical plants

Specific objectives:
- Modifications on the basic PID
- Wind-up effect in the integrator
- Limitation of the derivative gain
- Process models and tuning methods
- Digital implementation of a PID

Related activities:
A practical session devoted to the use of MATLAB for advanced controller design

Full-or-part-time: 21h
Theory classes: 6h
Laboratory classes: 2h
Self study : 13h

-Multivariable control

Description:
Generalise the concept of transfer function for systems with multiple inputs and outputs and introduce analysis and design tools for this type of systems

Specific objectives:
- External description of the multivariable systems
- Analytical tools for multivariable systems
- Design tools of controllers for multivariable systems

Related activities:
Half practical session will be dedicated to the use of MATLAB for the analysis of dynamic systems

Full-or-part-time: 13h
Theory classes: 4h
Laboratory classes: 1h
Self study : 8h

-Measure and instrumentation in chemical processes

Description:
Study of the own instrumentation of the chemical industry and introduction to data acquisition and signal processing

Specific objectives:
- General characteristics of sensors and actuators
- Sensors and actuators of the chemical industry

Related activities:
Half lab session

Full-or-part-time: 9h 30m
Theory classes: 2h
Laboratory classes: 1h
Self study : 6h 30m

ACTIVITIES

PRACTICE 1

Description:
Study and usage of MATLAB tools for the analysis and simulation of a chemical system

Material:
Computer with MATLAB

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

PRACTICE 2

Description:
Analysis of the response and stability of systems in open loop and closed loop in the time and frequency domains

Material:
Computer with MATLAB

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

PRACTICE 3

Description:
Analysis, modelling and design of a classic controller for a thermal system

Material:
Thermal system of the lab and associated control system

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

PRACTICE 4

Description:
Study and use of the MATLAB tools for the analysis and design of controllers through internal representation and multivariable systems

Material:
Computer with MATLAB

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

PRACTICE 5

Description:
Study and use of the MATLAB tools for the digital control and the design of advanced controllers

Material:
Computer with MATLAB

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

PRACTICE 6

Description:
Implementation of the advanced concepts of control applied to the lab systems

Material:
Thermal system of the lab and associated control systems

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

GRADING SYSTEM

Subject in process of extinction. There is only one final test that corresponds to 100% of the final grade of the subject.

EXAMINATION RULES.

To do the exams, students can have one sheet of notes (two pages DIN A4), the s and z transform tables, and a calculator.

BIBLIOGRAPHY

Basic:
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- Costa Castelló, R.; Fossas Colet E. Sistemes de control en temps discret [on line]. Barcelona: Editions UPC, 2012 [Consultation: 22/05/2020]. Available on: http://hdl.handle.net/2099.3/36857. ISBN 9788498804638.
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- Kuo, Benjamin C. Digital control systems. 2nd ed. Oxford: Oxford University Press, cop. 1992. ISBN 0195120647.

Complementary:
- Åström, Karl J.. Control PID avanzado. Madrid: Pearson Educación, 2009. ISBN 9788483225110.
- Skogestad, S.; Postlethwaite, I. Multivariable feedback control : analysis and design. 2nd ed. Chichester: Wiley, 2005. ISBN 9780470011683.
- Ollero de Castro, P.; Fernández, E. Control e instrumentación de procesos químicos. Madrid: Síntesis DL, 1997. ISBN 8477385173.
- Luyben, William L.. Process modeling, simulation, and control for chemical engineers. 2nd ed. New York: McGraw-Hill, 1990. ISBN 0071007938.