Course guide
820012 - CIA - Industrial Control and Automation

Last modified: 28/06/2023

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

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: JOAQUIM BLESA IZQUIERDO
JORDI SOLA SOLER

Others: Primer quadrimestre:
MARÍA DOLORES BLANCO ALMAZÁN - Grup: M11, Grup: M12, Grup: M41, Grup: M42
JOAQUIN BLESA IZQUIERDO - Grup: M11, Grup: M12, Grup: M31, Grup: M32, Grup: M33, Grup: M34, Grup: M35
JOAN DOMINGO PEÑA - Grup: M21, Grup: M22, Grup: M31, Grup: M32, Grup: M41, Grup: M42, Grup: M43, Grup: M44
MANUEL LOZANO GARCÍA - Grup: M21, Grup: M22, Grup: M31, Grup: M32
DAVID MARTÍNEZ ESCACHX - Grup: M23, Grup: M24, Grup: M33, Grup: M34
FRANCESC MELIÀ SUÑÉ - Grup: M25, Grup: M35
JOAN OLLÉS PADILLA - Grup: T11, Grup: T12, Grup: T13, Grup: T14
VICTOR REPECHO DEL CORRAL - Grup: M41, Grup: M42, Grup: M43, Grup: M44, Grup: T11, Grup: T12, Grup: T13, Grup: T14
JAIME JESÚS RIBA ARROYO - Grup: T23, Grup: T24
ALEJANDRO ROLÁN BLANCO - Grup: M21, Grup: M22, Grup: M23, Grup: M24, Grup: M25
DANIEL ROMERO PEREZ - Grup: M43, Grup: M44, Grup: T21, Grup: T22
JOAN SEGURA CASANOVAS - Grup: M31, Grup: M32, Grup: M33, Grup: M34, Grup: M35, Grup: T21, Grup: T22, Grup: T23, Grup: T24
JORDI SOLA SOLER - Grup: T21, Grup: T22, Grup: T23, Grup: T24

Segon quadrimestre:
JOAQUIN BLESA IZQUIERDO - Grup: M31, Grup: M32, Grup: M33, Grup: M34
DAVID MARTÍNEZ ESCACHX - Grup: M13, Grup: M14, Grup: M23, Grup: M24
FRANCESC MELIÀ SUÑÉ - Grup: M33, Grup: M34
JOAN OLLÉS PADILLA - Grup: M31, Grup: M32, Grup: T21, Grup: T22
FLAVIO PALMIERI - Grup: M11, Grup: M12
VICTOR REPECHO DEL CORRAL - Grup: T21, Grup: T22, Grup: T23
JAIME JESÚS RIBA ARROYO - Grup: T11, Grup: T12, Grup: T13, Grup: T23
ALEJANDRO ROLÁN BLANCO - Grup: M11, Grup: M12, Grup: M13, Grup: M14, Grup: T11, Grup: T12, Grup: T13
DANIEL ROMERO PEREZ - Grup: M21, Grup: M22
JORDI SOLA SOLER - Grup: M21, Grup: M22, Grup: M23, Grup: M24

PRIOR SKILLS

For good follow the subject, is recommended to have passed the following subjects:
- Mathematics (I and II)
- Physics
- Electrical Systems
- Mechanical systems
- Graphic expression
- Computer Basics

REQUIREMENTS

SISTEMES ELÈCTRICS - Corequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEI-12. Understand the fundamentals of automatic control methods.

Transversal:
1. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
2. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

TEACHING METHODOLOGY

The course uses approximately methodology expositive/participative by 25%, the 50% is individual work, and group work by 25%. We also used the techniques of cooperative learning and project/problem-based learning. The practical realization is important to better understand the concepts worked.

LEARNING OBJECTIVES OF THE SUBJECT

1. Acquire basic skills in design, analysis and implementation of automated systems.
2. Knowing different devices, components and systems involved in the process automation industry.
3. Making an industrial automation PLC based.
4. Know the basics of continuous systems dynamics.
5. Know methods of regulation and control of continuous systems.
6. Teamwork.
7. Efficient use of information resources in the field of automation of industrial processes.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	30.00
Hours small group	15,0	10.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

- Unit 1_1

Description:
Introduction to industrial automation. Control and regulation. Type of automation. Law of command. Part of command and operational part. Basic architecture of control systems in open loop and closed loop.

Specific objectives:
Upon completion of the activities students will be able to:
- Be able to explain the scope and content of the subject and details relating to staff, weekly dedication, practices scheduling, assessment system and bibliography.
- Make a definition of Control Law using quality criteria.
- Differentiate open loop from closed loop control.
- Be aware of the scope and usefulness of industrial automation and its consequences.
- Be able to differentiate single-phase and tri-phase systems, and use and explain protections of electrical installations.

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 9h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 5h

- Unit 1_2

Description:
Sensors; classification, characteristics, and connection type.

Specific objectives:
Upon completion of the activities the student will be able to:
- Differentiate sensor from transducer.
- Learn the most common sensors and ways of wiring.

Related activities:
Information search
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 9h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 5h

- Unit 1_3

Description:
GRAFCET: elements and structures. Schematic with ladder. Deploying wired and programmable automation. Examples.

Specific objectives:
Upon completion of the activities the student will be able to:
- Being able to explain what is a GRAFCET.
- Know the most common GRAFCET structures.

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 9h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 5h

- Unit 1_4

Description:
Actuator's: types and connection. Electric, pneumatic and hydraulic. Electrovalves.

Specific objectives:
At the end of the activities the student will be able to:
- Differentiate the different types of actuators.
- Latching-relays as memory circuits.
- Be able to make schematic connection of actuators and pre-actuators.

Related activities:
Information search
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 10h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 6h

- Unit 2_1

Description:
Introduction to PLC.

Specific objectives:
Upon completion of the activities the student will be able to:
- Understand PLC types.
- Write a PLC program.
- Identify the elements of the PLC programming language.
- Know what are the languages of IEC 61131.

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 12h
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 6h
Self study : 2h

- Unit 2_2

Description:
PLC: Architecture. Scan Cycle. Configurations. Memory Structure. Software elements.

Specific objectives:
Upon completion of the activities the student will be able to:
- Explain what is a Programmable Logic Controller (PLC) and its use in automation systems.
- Understand the internal architecture of a PLC.
- Explain characteristics of this technology in relation to other technologies
- Be able to write simple PLC programs
- Explain what is a PLC scan cycle.
- Explain how the PLC memory is structured and its addressing systems.

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 9h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 5h

- Unit 2_3

Description:
PLC Programming: combinational elements and sequences with scales, timers, counters and others. Analog part of PLCs and connection to and from analog components. Control of induction motors with inverters; connection and programation. Examples.

Specific objectives:
Upon completion of the activities the student will be able to:
- Programming a PLC using ladder diagrams.
- Use the programming resources of a PLC.
- Explain how the PLC memory map is distributed.
- Connect sensors and actuators, digital and analog, to a PLC.
- Use timers and counters of a PLC.
- Know, connect and program frequency inverters to induction motors.

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 10h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 6h

- Unit 3_1

Description:
Difference between automation and control. Continuous systems. Analog signal. Modelling. Transformations from time to frequency domain. Basic criteria of stability. Systems of order 0, 1 and 2. Higher order systems. Time response of continuous systems.

Specific objectives:
At the end of the activities the student will be able to:
- Differentiate automation from control
- Be able to explain what systems order 0, 1 and 2 are, and how they respond
- Recognize whether a system is stable or not
- Identify the behavior of a system and the type of response from the canonical functions
- Establish the equivalent mathematical model of simple physical system

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 20h
Theory classes: 5h
Laboratory classes: 2h
Guided activities: 1h
Self study : 12h

- Unit 3_2

Description:
Transfer functions. Block diagrams. Simulation and simulators. Stability: poles and zeros and consequences of their position in the complex plane. Root locus (Evans graph), stability criteria of Routh-Hurwitz and Nyqvist. Compensation of poles and zeros. Cases and examples.

Specific objectives:
Upon completion of the activities the student will be able to:
- Make "s" transfer functions from differential equations.
- Build and simplify block diagrams.
- Use a simulator as help of characterization of systems
- To determine the stability of a system in open and closed loop

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 21h 30m
Theory classes: 6h
Laboratory classes: 2h
Guided activities: 1h 30m
Self study : 12h

- Units 3_3 & 3_4

Description:
Effects of open and closed loop. Continuous regulators. Actions P, I, D, PI, PD, PID. Effect of each action on a system. PID tuning criteria, Ziegler-Nichols and variants.

Specific objectives:
At the end of the activities the student will be able to:
- Recognize the effect of P, I and D actions and their combination
- Tune a regulator
- Discussion of the stability of open and closed loop systems
- Use simulators
- Perform practically a PID control of a second order system with a PLC as a regulator

Related activities:
Laboratory practice
Classroom problem sessions
Homework problems

Full-or-part-time: 10h 30m
Theory classes: 3h
Laboratory classes: 1h
Guided activities: 0h 30m
Self study : 6h

- Unit 4 (Project)

Description:
Resolution of a project. The Gantt diagram. Team work. The documentation of the projects. Work methodologies
Make a project of automation with PLC justifying calculations, selection of materials, GRAFCETs, securities, programs, electrical diagrams, connection to PLC, use of expansion modules of inputs and outputs, digital and analog, KOP, preparation of budget and calculation of energy consumption.

Specific objectives:
At the end of the activities the student will be able to:
- Do a full automation project.
- Make Gantt charts.
- Make project reports.
- Teamwork.
- Search and find information related to the materials of the project.

Related activities:
Complete reading of this guide (without annexes)
Elaboration of a Gantt diagram
Teamwork rules
Objectives to attain
Completion of a technical report sections
Sending to Atenea

Full-or-part-time: 25h
Theory classes: 3h
Guided activities: 2h
Self study : 20h

- Unit 5

Description:
Introduction to data acquisition systems, supervision and control. Basic Elements. Distribution of basic elements and communication between them. The graphical interface with the latest features and typical components. Data acquisition and control variables: characteristics and configuration. Introduction to industrial communications.

Specific objectives:
Upon completion of the activities the student will be able to:
- Explain what we mean by data acquisition system, supervision and control, and what are its basic elements.
- Recognize the responsibility of a control and monitoring system on the operation of the controlled plant.
- Explain the basic capabilities offered by commercial monitoring and control software and its use.

Related activities:
Problem sessions
Homework problems

Full-or-part-time: 2h
Theory classes: 1h
Self study : 1h

GRADING SYSTEM

- Partial Exams: 50% (25% each of the 2 that will be carried out)
- Practice control: 10%
- Exercises and class room problems: 12.5%
- Practices: 15%
- Competence "efficient use of information resources": 6.25%. This competency must be demonstrated by the complete and correct selection of the components of the course project.
- Course project. 6.25%.

This subject has no re-evaluation because it is based on a continuous assessment system in which each student has to add up grades throughout the course, many of them derived from teamwork both in class and out of class.

EXAMINATION RULES.

No further delivery to the campus, or in hand when this is proposed, which is made entirely by computer and office tools, and PDF format file. Only be given exercises hand writted when carried out in the same class session. Which are outside of class, will always be machine made and PDF.

Practices are hand delivered solved unless otherwise indicated.

For partial controls, one page, with annotations only for one side, will be allowed for issues which should not be relied on in memory and, if necessary, a scientific calculator. It is completely forbidden to use mobile telephony. In case of need to wait for a telephone call o message, the professor must be notified before the exam.

BIBLIOGRAPHY

Basic:

- Goodwin, Graham C; Graebe, Stefan F; Salgado, Mario E. Control system design. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0139586539.
- Ogata, Katsuhiko. Ingeniería de control moderna [on line]. 5ª ed. México D.F. [etc.]: Prentice-Hall Hispanoamericana, 1998 [Consultation: 21/04/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1259. ISBN 9788483229552.
- Dorf, Richard C. Sistemas de control moderno. 10a ed. Madrid [etc.]: Prentice Hall, cop. 2005. ISBN 8420544019.
- Kuo, Benjamin C.. Sistemas de control automático. México: Prentice Hall, 1996. ISBN 9688807230.
- Balcells Sendra, Josep; Romeral Martínez, José Luís. Autómatas programables. Barcelona: Marcombo, 1997. ISBN 84-2671-089-1.
- Lewis, Paul H.; Yang, Chang. Sistemas de control en ingeniería. Madrid [etc.]: Prentice Hall, 1999. ISBN 8483221241.

Complementary:

- Bryan, L. A; Bryan, E.A. Programmable controllers : theory and implementation. 2nd ed. Atlanta: Industrial Text, cop. 1997. ISBN 094410732X.
- Mandado Pérez, Enrique [et al.]. Autómatas programables : entorno y aplicaciones. Madrid: International Thomson Paraninfo, cop. 2005. ISBN 8497323289.

RESOURCES

Computer material:

- Notes and materials for the course

Other resources:

Study material for each unit or topic of the subject related to the theory, practices and exercises.