Control system design

Lecturer
Emanuele GARONE (Coordinator)

Course mnemonic
MATH-H407

ECTS credits
5 credits

Language(s) of instruction
English

Course period
First term

Campuses
Solbosch and Plaine

Course content

Part I – Discrete time System Analysis *(~ 10 hours)*

1) **Definition and Basic Properties of Systems** - Definition of systems, representations of systems linear systems, their relationship and some notions on realizations. Zero Input Response and Zero State Response

2) **Lyapunov stability –** Definition of Stability, Local and Global Attractivity, Asymptotic Stability. Lyapunov direct Method, Krasovskii-Lasalle, Stability for LTI systems, Lyapunov indirect method, Relationship between Internal Stability and BIBO stability

3) **Reachability**:Definitions of Reachability and Controllability. State Feedback Control and Stabilizability.

4) **Observability:** - Definitions of Observability and Reconstructability. State Estimation and Observers. Detectability. Dynamical Compensator.

Part II - Sample Data System Analysis *(~ 4 hours)*

1) **Sampled Data Systems:** Sampling, Shannon Theorem, Reconstruction, Sampling of a System and related issues (antialiasing, sampling time, etc)

Part III - Discrete Time and Sample Data System Synthesis *(~ 10 hours)*

1) **"Classical" Synthesis methods for sampled data systems:** Specifications, Padé approximation, Discretization of continuous time controller, Discrete Time Root Locus, Discrete Time PID.

2) **"Industrial" control scheme:** Cascade and Feedforward Schemes, the internal model principle.

3) **System with Saturations:** Anti-windup schemes, Introduction to Model Predictive Control

Objectives (and/or specific learning outcomes)

The goals of this course are:

1) to give the methodological basis for the analysis both of **discrete time system** and of **sampled data systems**

2) to detail some of the **techniques** that may be used to **control** them

3) to make the student able to implement the above knowledge in the control of a **real plant**

Pre-requisits and co-requisits

Courses having this one as pre-requisit

MEMO-H502 | Master thesis in Electromechanical Engineering | 24 crédits and STAG-H502 | Internship (40 days) | 6 crédits

Required knowledge and skills

It is fundamental a good understanding of basic **linear algebra** (Vector and Matrix operations, Vector Spaces and Subspace, Span/Image and Kernel/NullSpace of a matrix, eigenvalues, diagonalization, solution of linear systems)

Basic **automatic control** (transfer function, the concept of feedback, basic control in the frequency domain)

Teaching method and learning activities

Lectures: Ex cathedra teaching using slides and blackboard.

Exercise Sessions: Individual exercises to fix the theoretical concept. The main goal of exercise is to be better understand the theory. Exercise will be done with the help of Matlab and will guided by the professor and the assistant.

Laboratory: Students will work in teams of 2-4 people. Each team will work on a plant. The goal is to makes use of the techniques shown in the lectures to control the plant in the most appropriate way.

Contribution to the teaching profile

This teaching unit contributes to the following competences:

- In-depth knowledge and understanding of exact sciences with the specificity of their application to engineering
- In-depth knowledge and understanding of integrated structural design methods in the framework of a global design strategy
- In-depth knowledge and understanding of the advanced methods and theories to schematize and model complex problems or processes
- Reformulate complex engineering problems in order to solve them (simplifying assumptions, reducing complexity)

- Present and defend results in a scientifically sound way, using contemporary communication tools, for a national as well as for an international professional or lay audience
- Work in an industrial environment with attention to safety, quality assurance, communication and reporting
- Develop, plan, execute and manage engineering projects at the level of a starting professional
- Think critically about and evaluate projects, systems and processes, particularly when based on incomplete, contradictory and/or redundant information
- A creative, problem-solving, result-driven and evidence-based attitude, aiming at innovation and applicability in industry and society
- A critical attitude towards one's own results and those of others
- Consciousness of the ethical, social, environmental and economic context of his/her work and strives for sustainable solutions to engineering problems including safety and quality assurance aspects
- The flexibility and adaptability to work in an international and/or intercultural context
- An attitude of life-long learning as needed for the future development of his/her career
- Has a profound knowledge of either (i) nano- and opto-electronics and embedded systems, (ii) information and communication technology systems or (iii) measuring, modelling and control.
- Is able to model, simulate, measure and control electronic components and physical phenomena.

References, bibliography and recommended reading

[1] www.gprix.it

[2] Chi-Tsong Chen, Linear System Theory and Design

[4] Hassan K. Khalil, Nonlinear Systems

[5] Katsuhiko Ogata : Discrete-Time Control Systems

[6] K.J. Astrom, B. Wittenmark, Computer Controlled Systems, Theory and Design

Course notes

Syllabus

Other information

Place(s) of teaching

Solbosch and Plaine

Contact(s)

Emanuele Garone, Service d'automatique et d'analyse des systèmes. Bât. L, porte E, 1er étage. egarone@ulb.ac.be

Evaluation method(s)

written examination and Group work

Evaluation method(s) (additional information)

Laboratory : Lab Experience Report + 20-30 minutes talk on the obtained results (Assessment: from 0 to 20)

Theory and Exercises : Written Exam (Assessment: from 0 to 22, minimum of 7 required to pass)

Determination of the mark (including the weighting of partial marks)

Theory and Exercises: 66.66 %

Laboratory Mark : 33.33 %

Main language(s) of evaluation

English

Programmes

Programmes proposing this course at the Brussels School of Engineering

MA-IREL | Master of science in Electrical Engineering | finalité electronics and information technologies/unit 1 and
MA-IREM | Master of science in Electromechanical Engineering | finalité Professional/unit 1 and finalité Operations engineering and management/unit 1