Course guide
230368 - MACA - Matlab Programed Arduino for Control Applications

Last modified: 06/05/2019

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: **Academic year:** 2019 **ECTS Credits:** 2.5
Languages: English

LECTURER

Coordinating lecturer: Rosa M. Fernández / Jose A. Lázaro

Others: Jose A. Lázaro / Rosa M. Fernández

TEACHING METHODOLOGY

Application examples solved in class via Matlab/Simulink and Arduino
Laboratory Practices
Final work and oral exposition of the solution obtained to the proposed problem

LEARNING OBJECTIVES OF THE SUBJECT

The aim of this course is to train students in methods for the design and analysis of digital controllers by means of the computer. The course includes a brief introduction to control theory for the students not familiar with this field and it is mainly developed on the basis of several application examples and case studies. The students will work with the Matlab/Simulink software. Finally, several laboratory experiments with ARDUINO will be performed.

Learning results of the subject:
- Ability to formulate the control problem specifications taking into account theoretical and practical constraints.
- Ability to design digital controllers by several software-based techniques: empirical methods, root locus, direct synthesis, and optimization.
- Ability to select, analyze and implement digital controllers by means of Arduino and Simulink.

STUDY LOAD

Type	Hours	Percentage
Hours large group	10,0	16.00
Hours small group	10,0	16.00
Self study	42,5	68.00

Total learning time: 62.5 h

CONTENTS

Unit 1. Fundamentals of Control Theory

Description:
1.1 Fundamentals of Control Theory.
1.2 Laplace modeling of dynamic systems. Linearization
1.3 System Response (time and frequency)
1.4 Feedback. Specifications
1.5 Matlab/Simulink tools for control systems analysis, design and implementation

Specific objectives:
Give minimum Control Theory concepts necessary to follow the course
Introduce Matlab/Simulink software for control systems analysis

Related activities:
Case Study 1. Antenna heading

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Unit 2. PID, Digital and Optimal Controllers

Description:
2.1 PID regulators: P, I, D actions. Zieglerâ□□Nichols tuning
2.2 Optimal tuning of PIDs
2.3 Design of optimal ITAE controllers by direct synthesis
2.4 Signal processing for digital control systems. Z Transform
2.5 Discretization of analog controllers
2.6 Deadbeat and Dahlin controllers

Specific objectives:
Learn different approaches and techniques to design linear controllers (empirical methods, optimization)
Learn how to discretize analog controllers and how to select a proper sampling time
Learn to design pure digital controllers by direct synthesis

Related activities:
Case study 2: Temperature regulation of an industrial oven

Full-or-part-time: 10h 50m
Theory classes: 2h 20m
Self study : 8h 30m

Unit 3. Software-based controller design in the complex plane

Description:
3.1 Analysis of Control Systems: Root locus
3.2 Stability analysis: Routhâ□□Hurwitz, Nyquist, margins
3.3 Performance analysis: Steady State Error Constants
3.4 Sisotool: Design of P, I, and PI controllers

Specific objectives:
Introduce the sisotool to design control systems in the complex plane

Related activities:
Case study 3: Magnetic levitator

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Unit 4. PRACTICE on MATLAB programed ARDUINO for Control Applications

Description:
4.1 Basics on ARDUINO
4.2 Programming ARDUINO with MATLAB/Simulink
4.3 Actuating and Monitoring Hardware using ARDUINO & MATLAB
4.4 Developing a Controller in ARDUINO with MATLAB

Specific objectives:
Gain practical handsâ□□on experience in building highâ□□level examples by oneself
Design, simulate and test custom algorithms in Simulink
Implement these algorithms on lowâ□□cost embedded hardware such as Arduino

Related activities:
Case study 4: Controlling a Tunable Laser or Electronic Circuit with ARDUINO & MATLAB.

Full-or-part-time: 25h
Theory classes: 17h
Self study : 8h

GRADING SYSTEM

Final examination: from 20% to 50%
Partial examinations and controls: from 0% to 50%
Exercises: from 0% to 20%
Laboratory assessments: from 0% to 50%

BIBLIOGRAPHY

Basic:
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- Kuo, B.C. Digital control systems. 2nd ed. Ft. Worth: Saunders College, 1992. ISBN 0030128846.
- Ogata, K. Discrete-time control systems. 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1995. ISBN 0133286428.
- Kailath, T. Linear systems. Englewood Cliffs, NJ: Prentice-Hall, 1980. ISBN 0135369614.
- Landau, I.D.; Zito, G. Digital control systems: design, identification and implementation [on line]. New York: Springer, 2006 [Consultation: 11/05/2020]. Available on: http://dx.doi.org/10.1007/978-1-84628-056-6. ISBN 1846280559.