Advanced Design Methods

Academic Year: (2022 / 2023) **Review date: 20-05-2022**

Department assigned to the subject: Department of Bioengineering and Aerospace Engineering

Coordinating teacher: MARCOS ESTEBAN, ANDRES

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is recommended to have taken all undergraduate courses related to control in aerospace and/or system engineering, and preferably modern control (state-space and optimal).

OBJECTIVES

This course provides space engineers with an in-depth introduction to robust control design methods with application to aerospace systems.

Robust design has a well-established tradition in the space and aeronautic fields, and has successfully been applied to various European Space missions (such as Ariane V) and satellites programmes (such as ESA's Mars & Venus Express).

The course will first review classical controls for single-input, single-output systems including the fundamentals of modern frequency domain loop shaping techniques. It will then cover more advanced robust control topics for multi-input, multi-output systems including robustness analysis (multi-loop disk margins / structured singular value) and optimal (H2/H-infinity) optimal control. The course reconciles theory and practice using real space mission examples and exercises (VEGA, Phobos).

DESCRIPTION OF CONTENTS: PROGRAMME

1) Presentation Study Cases & Review Classical Feedback Control (terminology, concepts, metrics, transfer functions, stability margins)
2) Loop-Shaping (frequency-domain design requirements, basic controller components, limits of performance)
3) State-Space Modeling & Linearization
4) SISO Robust Control (nominal performance, uncertainty modeling, small-gain theorem)
5) Robust Analysis (structure singular value, worst-case gain analysis)
6) MIMO Robust Control (MIMO margins, MIMO robust performance)
7) Optimal Control Design (theory, practice)
8) Examples of real projects and exercises: VEGA launcher, PHOBOS descent & landing, HIMAT, ORION CEV

LEARNING ACTIVITIES AND METHODOLOGY

The course consists of theory sessions, problem/example sessions, and guided work sessions in teams of two students.

The main activity of the course is the development and analysis of a controller for a spatial system (each of the students on a computer with a different method). This will take place in guided work sessions and in out-of-class work hours.

The work of the students will be presented in written form (individual document to be delivered on the date of examination) and continuous (draft versions of the documents)

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- Benjamin C. Kuo Automatic control systems, Prentice-Hall, 1995

- Norman S. Nise Control systems engineering , Wiley, 2019
- S. Skogestad and I. Postlethwaite, Multivariable feedback control analysis and design, , Wiley, 1996

ADDITIONAL BIBLIOGRAPHY

- Doyle, Francis, Tannenbaum Feedback Control Theory, https://sites.google.com/site/brucefranciscontact/Home/publications.
- Maciejowski, Jan Multivariable Feedback Design, Addison-Wesley, 1989