Engineering Tripos Part IIB, 4F2: Robust and Nonlinear Control, 2021-22

Module Leader

Prof R Sepulchre [1]

Lecturers

Prof R Sepulchre and Dr F Forni [2]

Timing and Structure

Lent term. 14 lectures + 2 computer lab sessions. Assessment: 100% coursework

Prerequisites

3F2 assumed.

Aims

The aims of the course are to:

- introduce fundamental concepts from nonlinear dynamic systems
- introduce techniques for the analysis and control of nonlinear and multivariable systems.

Objectives

As specific objectives, by the end of the course students should be able to:

- apply standard analysis and design tools to multivariable and nonlinear feedback systems.
- appreciate the diversity of phenomena in nonlinear systems.

Content

Part I. ROBUST CONTROL (7L + 1 Computer Lab session, Prof R. Sepulchre)

1. Uncertainty and Nonlinearity in control systems: simple models.

2. Signal spaces and system gains.

3. The small-gain theorem and the passivity theorem. Phase versus gain uncertainties

4. Dissipativity theory

5. Robust stability and performance. Stability margins.

6. An introduction to H-infty control.

7. Gap metrics

PART 2: NONLINEAR SYSTEMS (7L + 1 computer lab session, Dr F Forni)

1. Small and large signal analysis. Contractive systems. Fading memory operators.

2. State-space analysis and Nyquist. Differential stability. Differential dissipativity. Differential circle criterion.

3. Feedback systems: simple models.

4. Phase portrait analysis.

5. Analysis and design of switches and clocks. Robust differential control.

6. Monotone systems. Contraction of cones. Polyhedral cones. Applications in biology.

7. Describing function analysis.

Further notes

ASSESSMENT

Coursework only.

Coursework

Coursework	Format	Due date & marks
[Coursework activity #1 Robust control of haptic interfaces Coursework 1 brief description Learning objective: • Learn how to model uncertainty in an engineering application • Design a robust controller in Matlab	Individual Report anonymously marked	25 February [30/60]
[Coursework activity #2 Feedback oscillations control] Coursework 2 brief description Learning objective: • Learn how to model and analyse nonlinear oscillations in feedback systems • Design a nonlinear oscillator in a biologically motivated appication	Individual Report anonymously marked	25 March 20 [30/60]

Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D4

Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

Last modified: 27/09/2021 09:29

Source URL (modified on 27-09-21): https://teaching21-22.eng.cam.ac.uk/content/engineering-tripos-part-iib-4f2-robust-and-nonlinear-control-2021-22

Links
[1] mailto:rs771@cam.ac.uk
[2] mailto:rs771@cam.ac.uk, ff286@cam.ac.uk,
[3] https://teaching21-22.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching21-22.eng.cam.ac.uk/content/uk-spec