Engineering Tripos Part IIB, 4F2: Robust & Nonlinear Systems & Control, 2019-20

Module Leader

Prof RJCPM Sepulchre [1]

Lecturers

Prof RJCPM Sepulchre and Dr I Lestas [2]

Timing and Structure

Lent term. 14 lectures + 2 examples classes. Assessment: Exam only

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 1: MULTIVARIABLE FEEDBACK SYSTEMS (7L + 1 example class, Prof R. Sepulchre)

- Performance measures for multi-input/multi-output systems.
- Stabilization: stability conditions, all stabilizing controllers, small gain theorem.
- Models for uncertain systems.
- Robust stability and performance. Loop shaping design.
- Design of multivariable systems.

PART 2: NONLINEAR SYSTEMS (7L + 1 example class, Dr I Lestas)

- Linear and Nonlinear systems; feedback circuits.
- Differential equations and trajectories.
- Multiple equilibria, limit cycles, chaos and other phenomena.
- Examples from biology and mechanics.

- State space stability analysis:
- The theorems of Lyapunov, LaSalle invariance principle.
- Stability of nonlinear circuits and neural behaviors.
- State-space tools for robustness analysis.
- Input/output stability analysis:
- Describing functions
- Small gain theorems, circle and Popov criteria, passivity.

Further notes

ASSESSMENT

Lecture Syllabus/Written exam (1.5 hours) - Start of Easter Term/100%

Booklists

Please see the Booklist for Group F Courses [3] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [4].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [5] 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.

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Links
[1] mailto:rs771@cam.ac.uk
[2] mailto:rs771@cam.ac.uk, icl20@cam.ac.uk,
[3] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=55881
[4] https://teaching25-26.eng.cam.ac.uk/content/form-conduct-examinations
[5] https://teaching25-26.eng.cam.ac.uk/content/uk-spec