Engineering Tripos Part IIB, 4F1: Control System Design, 2019-20

Module Leader

Prof MC Smith [1]

Lecturer

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Timing and Structure

Michaelmas term. 12 lectures + 2 examples classes + coursework. Assessment: 75% exam/25% coursework

Prerequisites

3F1 and 3F2 useful

Aims

The aims of the course are to:

- establish for the students a fundamental approach to the design of linear control systems.

Objectives

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

- understand the role and importance of feedback for the control of uncertain dynamical systems.
- demonstrate the information conveyed via root locus diagrams for transient behaviour and basic frequency response analysis using Nyquist (polar) and Bode plots.
- following its basic derivation, illustrate the use of the Nyquist stability criterion with both open loop stable and open loop unstable systems;
- understand factors which limit achievable performance in feedback systems.
- use analytical tools to understand trade-offs (e.g. Bode gain/phase relations, sensitivity integrals).
- translate general requirements for robustness and performance into specifications on the open-loop frequency response.
- use computer software for simple control system design and system simulation
- design simple compensators to achieve such specifications.

Content

Control system design (11L)

- System dynamics, stability and instability, principles and use of root locus plots, derivation of Nyquist

stability criterion, Bode theorems and plots.
- Design of simple P.I.D. controllers and phase compensators. Sensitivity, complementary sensitivity and SISO robustness. Non-minimum phase systems and limitations, bandwidth. Delays in systems.
- Two degree of freedom design.

Introduction to Coursework (1L)

Case studies and simulation.

Coursework

Case studies and design by simulation and computer software, e.g. use of Matlab. Four hours DPO time plus report (further four hours).

Coursework	Format	Due date & marks
[Coursework activity #1 title / Interim] Coursework 1 brief description Learning objective: • •	Individual/group Report / Presentation [non] anonymously marked	day during te Thu week 3 [xx/60]
[Coursework activity #2 title / Final] Coursework 2 brief description Learning objective: • •	Individual Report anonymously marked	Wed week 9 [xx/60]

Booklists

Please see the Booklist for Group F Courses [2] for references for this module.

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.

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Links
[1] mailto:mcs1000@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=55871
[3] https://teaching23-24.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching23-24.eng.cam.ac.uk/content/uk-spec