Engineering Tripos Part IB, 2P6: Linear Systems and Control, 2018-19

Lecturer

Dr I Lestas [1]

Timing and Structure

Weeks 1-4 and 7-8, 2 lectures/week. Weeks 5-6, 1 lecture/week. 14 lectures.

Aims

The aims of the course are to:

- Introduce and motivate the use of feedback control systems.
- Introduce analysis techniques for linear systems which are used in control, signal processing, communications, and other branches of engineering.
- Introduce the specification, analysis and design of feedback control systems.
- Extend the ideas and techniques learnt in the IA Mechanical Vibrations course.

Objectives

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

- Develop and interpret block diagrams and transfer functions for simple systems.
- Relate the time response of a system to its transfer function and/or its poles.
- Understand the term 'stability', its definition, and its relation to the poles of a system.
- Understand the term 'frequency response' (or 'harmonic response'), and its relation to the transfer function of a system.
- Interpret Bode and Nyquist diagrams, and to sketch them for simple systems.
- Understand the purpose of, and operation of, feedback systems.
- Understand the purpose of proportional, integral, and derivative controller elements, and of velocity feedback.
- Possess a basic knowledge of how controller elements may be implemented using operational amplifiers, software, or mechanical devices.
- Apply Nyquist's stability theorem, to predict closed-loop stability from open-loop Nyquist or Bode diagrams.
- Assess the quality of a given feedback system, as regards stability margins and attenuation of uncertainty, using open-loop Bode and Nyquist diagrams.

Content

	Section numbers in books		
	(1)	*(2)*	*(3)*
Examples of feedback control systems. Use of block diagrams. Differential equation models. Meaning of 'Linear System'.	*1.1-1.11, 2.2-2.3*	*1.1-1.3, 2.1-2.6.1*	*1.1-1*
Review of Laplace transforms. Transfer functions. Poles (characteristic roots) and zeros. Impulse and step responses. Convolution integral. Block	*2.4-2.6*	*3.1-3.2*	*3.8-3* *6.1-6*

diagrams of complex systems.			
Definition of stability. Pole locations and stability. Pole locations and transient characteristics.	5.6, 6.1	3.3-3.4, 4.4.1	5.1-5
Frequency response (harmonic response). Nyquist (polar) and Bode diagrams.	8.1-8.3	6.1	6.5, 15.1
Terminology of feedback systems. Use of feedback to reduce sensitivity. Disturbances and steady-state errors in feedback systems. Final value theorem.	4.1-4.2, 4.4-4.5	4.1	9.2,
Proportional, integral, and derivative control. Velocity (rate) feedback. Implementation of controllers in various technologies.	10.6, 12.6	4.2	
Nyquist's stability theorem. Predicting closed-loop stability from open-loop Nyquist and Bode plots.	9.1-9.3	6.3	11.1
Performance of feedback systems: Stability margins, speed of response, sensitivity reduction.	6.3, 8.5, 9.4, 9.6, 12.5, 12.8-12.9	6.4, 6.6, 6.9	10.4, 15.6

REFERENCES

(1) DISTEFANO, J.J., STUBBERUD, A.R. & WILLIAMS, I.J. FEEDBACK AND CONTROL SYSTEMS
(2) FRANKLIN, G.F., POWELL; J.D. & EMAMI-NAEINI, A. FEEDBACK CONTROL OF DYNAMIC SYSTEMS
(3) OPPENHEIM, A.V., WILLSKY, A.S. & NAWAB, S.H. SIGNALS AND SYSTEMS
(4) ÅSTRÖM, K.J. & MURRAY, R.M. FEEDBACK SYSTEMS: AN INTRODUCTION FOR SCIENTISTS AND ENGINEERS
(5) DORF, R.C. & BISHOP, R.H. MODERN CONTROL SYSTEMS

Booklists

Please see the Booklist for Part IB Courses [2] for references for this module.

Examination Guidelines

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

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [5] which sets out the standard for degree accreditation.

The Output Standards Matrices [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links

[1] mailto:icl20@cam.ac.uk

[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=43771

[3] http://teaching.eng.cam.ac.uk/content/form-conduct-examinations

[4] http://www.engc.org.uk/ukspec.aspx

[5] http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/

[6] http://teaching.eng.cam.ac.uk/content/output-standards-matrices