

ES9ZP-15 Systems Modelling and Control

26/27

Department

School of Engineering

Level

Taught Postgraduate Level

Module leader

Mathias Foo

Credit value

15

Module duration

10 weeks

Assessment

100% coursework

Study location

University of Warwick main campus, Coventry

Description

Introductory description

Systems Modelling and Control (for MSc courses)

[Module web page](#)

Module aims

Most disciplines of the engineering profession require a sound understanding of the techniques used in the modelling and control of dynamic, multi-domain physical, and other, systems. The aims of this module are: to build on techniques and computer tools for modelling, predicting and analysing the behaviour of dynamic systems; and to build on concepts, principles and techniques employed in classical methods of single loop feedback control system design.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

The module will focus on a broad and generic systems approach to understanding physical systems modelling and their control. Techniques for systems analysis, approaches to systems modelling and the techniques for the simulation of systems models will be considered together with control algorithms and the conditions for which a system is controllable. In particular, a rigorous approach to the application of physical laws to formulate appropriate dynamical systems representations, and their subsequent analysis using linear and nonlinear methods, will be taught. The application of appropriate computational tools for systems analysis and simulation will naturally be included. The examples presented will be drawn from a range of different engineering disciplines ranging from mechanical and electrical to biological systems to illustrate the advantages of a systems approach.

In particular the module includes:

System modelling and analysis in time domain: review of systems modelling (1st and 2nd order) linking behavior to physical parameters, block diagrams, signal-flow graphs, system classification, input-output models, free and forced responses, transient and steady state responses, poles, Argand diagram.

System modelling and analysis in complex frequency domain: transfer function analysis, Laplace transform, initial and final value theorems, characteristic polynomial, stable/unstable/marginally stable systems with examples, systems modes; system representation: convolution in time domain, unit impulse and unit step responses and their applications.

Frequency domain analysis: frequency response, steady state frequency response, gain and phase, graphical representations of frequency response, magnitude and phase, Bode plots, Nyquist plots, links between time-domain specifications and frequency domain specifications; stability analysis using root locus, Nyquist plot, and Bode plots; robustness characterization using gain margin and phase margin.

Systems control: stability and feedback, feedback systems, open-loop and closed loop transfer functions, root locus plots, Nyquist stability criterion, conditionally stable systems, phase crossover frequency and gain margin, gain crossover frequency and phase margin, feedback control of linear systems, PID controllers, conditions on controllers parameters for their optimal performance, realizable controllers.

State space modelling and analysis: state space description, linear state space models, transfer function, transient response, characteristic equation and stability, system diagonalization and normal modes, stiff systems; nonlinear systems: equilibrium points/steady states, linearization around equilibrium points, Jacobian matrices, stability; state space analysis: systems controllability and observability, controllability and observability matrices, rank criteria, system in a diagonal form and normal modes, relationship with transfer function, minimal realization of a system; state feedback: feedback control and stability.

Computer tools for modelling: simulating and analysing dynamical systems in MATLAB/Simulink.

Learning outcomes

By the end of the module, students should be able to:

- Develop state space models for both linear and nonlinear systems, and utilize appropriate

techniques to perform state space analysis including design of state space feedback control systems. [M1, M2, M3]

- Develop mathematical models of physical systems using appropriate physical laws and expressing the models with ordinary differential equations, utilise engineering analysis to demonstrate commonality in behaviour. [M2, M6]
- Apply analytical techniques for analysing the response of both linear and nonlinear systems in time and frequency domain to a range of inputs. [M1, M3]
- Utilise computational methods (MATLAB/Simulink) to analyse and predict dynamical behaviour of physical systems (e.g. steady-state and transient response to a range of inputs) including stability performance analysis. [M3]
- Utilise computational methods in MATLAB/Simulink to apply concepts and techniques for analysis of the behaviour of open loop physical systems, and to design feedback control systems (PID), analyse their behaviour and assess their stability. [M3, M12]
- Apply teamwork skills to design an effective feedback control system [C16, M16]

Indicative reading list

[Reading lists can be found in Talis](#)

Subject specific skills

Ability to apply relevant practical and laboratory skills

Ability to be pragmatic, taking a systematic approach and the logical and practical steps necessary for, often complex, concepts to become reality

Transferable skills

Numeracy: apply mathematical and computational methods to communicate parameters, model and optimize solutions.

Apply problem solving skills, information retrieval, and the effective use of general IT facilities.

Overcome difficulties by employing skills, knowledge and understanding in a flexible manner

Be professional in their outlook, be capable of team working, be effective communicators, and be able to exercise responsibility and sound management approaches.

Study

Study time

Type	Required
Lectures	9 sessions of 1 hour (6%)
Total	150 hours

Type	Required
Supervised practical classes	9 sessions of 2 hours (12%)
Private study	123 hours (82%)
Total	150 hours

Private study description

123 hrs guided independent learning

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A1

Weighting Study time Eligible for self-certification

Assessment component

Control Design Problem - Group Project	50%	No
Students submit 12-page report + Simulink/Matlab code.		

Reassessment component

Control Design Problem - Individual Project		Yes (extension)
Students submit 12-page report + Simulink/Matlab code.		

Assessment component

ES9ZP in-class test: Matlab/Simulink skills.	50%	No
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Reassessment component is the same

Feedback on assessment

- Support through advice and feedback hours.

- Group-level feedback on assignment
 - Cohort-level feedback on in-class test.
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Availability

Anti-requisite modules

If you take this module, you cannot also take:

- ES3C8-15 Systems Modelling and Control

Courses

This module is Optional for:

- Year 1 of TESA-H800 Postgraduate Taught Biomedical Engineering
- Year 1 of TESA-H643 Postgraduate Taught Electrical Power Engineering