Unit 5021: Further Control Systems Engineering

Unit Code: M/651/0886

Level: 5

Credits: 15

Introduction

Control engineering is usually implemented at the top level of large projects, determining the engineering system performance specifications, the required interfaces, and hardware and software requirements. In most industries, stricter requirements for product quality, energy efficiency, pollution level controls and the general drive for improved performance, place tighter limits on control systems.

A reliable and high-performance control system depends a great deal upon accurate measurements obtained from a range of transducers, mechanical, electrical, optical and, in some cases, chemical. The information provided is often converted into digital signals on which the control system acts to maintain optimum performance of the process.

The aim of this unit is to provide the student with the further knowledge of the principles of control systems and to advance understanding of how these principles can be used to model and analyse simple control systems found in industry. The study of control engineering is essential for most engineering disciplines, including electrical, mechanical, chemical, aerospace, and manufacturing.

On successful completion of this unit students will be able to devise a typical three-term controller for optimum performance, grasp several control techniques and how these can be used to predict and control the behaviour of a range of engineering processes in a practical way.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Explain concepts and contemporary applications of control systems

LO2 Analyse the elements of a high-level control system and its model development

LO3 Evaluate the structure and behaviour of high-level control systems

LO4 Examine the application of control parameters to produce optimum performance of a control system.

Essential Content

LO1 **Explain concepts and contemporary applications of control systems**

Background, terminology, underpinning principles, and system basics:

Control system terminology and identification, including plant, process, system, disturbances, inputs and outputs, initial time, additivity, homogeneity, linearity and stability

Control systems properties and configurations, classification and performance criteria of control systems

Block diagram representation of control systems and their relevance in industrial application

Principles of Transfer Function (TF) for open and closed loop systems, use of current computational tools for use in control systems (e.g., MATLAB, Simulink, LabVIEW)

Latest methods of using data for control systems and applications − data collection systems, data formats, documentation control processes and procedures (e.g., location, access, authorisation)

Control systems and Industry 4.0 – relevance and impact on organisations.

LO2 **Analyse the elements of a high-level control system and its model development**

Developing system applications:

Simple mathematical models of electrical, mechanical, and electro-mechanical systems

Block diagram representation of simple control systems

Introduction of Laplace transform and its properties, simple first and second order systems and their dynamic responses

Modelling and simulation of simple first and second order control system using current computational tool (e.g., MATLAB, Simulink, LabVIEW).

LO3 **Evaluate the structure and behaviour of high-level control systems**

System behaviour:

Transient and steady behaviour of simple open loop and closed loop control systems in response to a unit step input

Practical closed loop control systems and the effect of external disturbances

Poles and zeros and their role in the stability of control systems, steady-state error. Applicability of Routh-Hurwitz stability criterion

Use of current computational tools (e.g., MATLAB, Simulink, LabVIEW) to model, simulate and analyse the dynamic behaviour of simple open and closed loop control systems.

LO4 **Examine the application of control parameters to produce optimum performance of a control system**

Control parameters and optimum performance:

Introduction to the three-term PID controller, the role of a Proportional controller (P), Integral controller (I) and the Derivative controller (D)

General block diagram representation and analysis, effects of each term, P-I-D, control applied to first and second order systems

Simple closed loop analysis of the different combinations of the terms in PID controllers, effect of the three terms on disturbance signals and an introduction to simple PID controller tuning methods

Modelling and simulation using current computational tools (e.g., MATLAB, Simulink, LabVIEW) to analyse the effects of each P-I-D term, individually and in combination on a control system

Overview of developments and future applications of using AI in supporting adaptive/self-learning control systems.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain concepts and contemporary applications of control systems		
P1 Explain a control system using block diagram representation and simplifications. **P2** Conceptualise a model of an open and closed loop control system using simulation.	**M1** Apply advanced modelling techniques to develop the block diagram of a closed loop system for the position control of DC motor using a PID controller.	**D1** Evaluate the performance of a PID controller for position control of a DC motor.
LO2 Analyse the elements of a high-level control system and its model development		
P3 Analyse the main building blocks for high-level electrical and mechanical control systems. **P4** Apply Laplace transforms to mechanical or electrical control problems.	**M2** Analyse Electrical, Mechanical and Electro-Mechanical control systems using appropriate mathematical models and simulation.	**D2** Critically evaluate complex electrical, mechanical and electromechanical control systems using mathematical models, control engineering methods and simulation.

Pass	Merit	Distinction
LO3 Evaluate the structure and behaviour of high-level control systems		
P5 Analyse the behaviour and response of first and second order systems. **P6** Evaluate the external effects on the stability of PID control systems and the techniques used to maintain stability in these systems.	**M4** Use analytical techniques to analyse how the stability of a dynamic PID control system.	**D3** Critically review the performance of a second-order electromechanical control system when subjected to external disturbances.
LO4 Examine the application of control parameters to produce optimum performance of a control system		
P7 Examine the role and implementation of the PID controllers in a simple electrical, mechanical, and/or electro-mechanical control systems. **P8** Synthesize the effects of the P, I, and D parameters on the dynamic responses of the first and second order systems.	**M5** Analyse dynamic responses of PID controllers in terms of position control, tracking and disturbance rejection.	**D4** Evaluate the behaviour of a second-order control system when PID terms are changed individually and in combination, using modelling and computer simulation techniques.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bolton W. (2021) *Instrumentation and Control Systems*. 3rd Ed. Elsevier.

Dabney J.B. and Harman T.L. (2003) *Mastering Simulink*. Prentice Hall.

Dorf R.C. and Bishop R.H. (2022) *Modern Control Systems*. 14th Ed. Pearson.

Essic J. (2018) *Hands-On Introduction to LabVIEW for Scientists and Engineers*. 4th Ed. Oxford University Press.

Iqbal K. (2020) *A First Course in Control System Design.* 2nd Ed. River Publishers.

Kondratenko Y.P, Kuntsevich V.M., Chikrii A.A. and Gubarev V.F. (2021) *Advanced Control Systems – Theory and Applications.* 1st Ed. River Publishers.

Moore H. (2019) *MATLAB for engineers.* 5th Ed. Pearson.

Nagrath I.J. (2022) *Control Systems Engineering.* 7th Ed. New Age International Publishers.

Nise N.S. (2011) *Control Systems Engineering*. 6th Ed. John Wiley & Sons.

Sarangapani J. and Xu H. (2021) *Optimal Networked Control Systems with MATLAB.* CRC Press.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Frontiers in Control Engineering

IEEE Open Journal of Control Systems

IFAC Journal of Systems and Control

Journal of Control Science and Engineering

Journal of Dynamic and Control Systems

Journal of Process Control.

Links

This unit links to the following related units:

Unit 4016: Instrumentation and Control Systems

Unit 5008: Distributed Control Systems.