Unit 54: Further Control Systems Engineering

Unit code	**Y/615/1522**
Unit level	**5**
Credit value	**15**

Introduction

Control engineering is usually found at the top level of large projects in 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 fundamental knowledge of the principles of control systems and the basic 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 fundamental 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

1. Discuss the basic concepts of control systems and their contemporary applications.
2. Analyse the elements of a typical, high-level control system and its model development.
3. Analyse the structure and behaviour of typical control systems.
4. Explain the application of control parameters to produce optimum performance of a control system.

Essential Content

LO1 **Examine the basic concepts of control systems and their contemporary applications**

Background, terminology, underpinning principles and system basics:

Brief history of control systems and their industrial relevance, control system terminology and identification, including plant, process, system, disturbances, inputs and outputs, initial time, additivity, homogeneity, linearity and stability

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

Block diagram representation of simple 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, Simuliunk, Labview)

LO2 **Explore the elements of a typical, 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)

LO3 Analyse the structure and behaviour of typical 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) to model, simulate and analyse the dynamic behaviour of simple open and closed loop control systems

LO4 Explain 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, on 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, Simuliunk, Labview) to analyse the effects of each P-I-D term, individually and in combination on a control system

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the basic concepts of control systems and their contemporary applications		**D1** Evaluate the performance of a PID controller to demonstrate basic control system techniques
P1 Examine the basic concepts of control systems using block diagram representation and simplifications **P2** Model simple open and closed loop control systems simulation software	**M1** Apply advanced modelling techniques using commercially available control software **M2** Develop the block diagram of a closed loop system for the position control of DC motor using a PID controller	
LO2 Explore the elements of a typical, high-level control system and its model development		**D2** Perform high-level self-tuning control system techniques using mathematical modelling and computer simulation
P3 Explore the main building blocks for high-level electrical and mechanical control systems **P4** Apply Laplace transforms to basic mechanical or electrical control problems	**M3** Analyse Electrical, Mechanical and Electro-Mechanical control systems using appropriate mathematical models and computer simulation	

Pass	Merit	Distinction
LO3 Analyse the structure and behaviour of typical control systems		**D3** Analyse the performance of an electro-mechanical control system when subjected to external disturbances
P5 Analyse the behaviour and response of first and second order systems **P6** Analyse the external effects on the stability of PID control systems and the techniques used to maintain stability in these systems	**M4** Evaluate using analytical techniques how the stability of a dynamic PID control system is maintained	
LO4 Examine the application of control parameters to produce optimum performance of a control system		**D4** Analyse the behaviour of a control system when P, I, D terms are changed individually and in combination using modelling and computer simulation techniques
P7 Examine the role and implementation of the PID controllers in a simple electrical and mechanical control system **P8** Examine 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	

Recommended Resources

Textbooks

DABNEY, J.B. and HARMAN, T.L. (2003) *Mastering Simulink*. Prentice Hall.

DORF, R.C. and BISHOP, R.H. (2014) *Modern Control Systems*. 12th Ed. Pearson.

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

Links

This unit links to the following related units:

Unit 41: Distributed Control Systems

Unit 16: Instrumentation and Control Systems