Control Fundamentals

Theory and Practice, and Future Directions
3-day Course, 12-14 November 2024, Glasgow

The Control Fundamentals Course Agenda has been developed and refined over two decades and has been presented multiple times at companies around the world. It is aimed at engineers that are using control techniques in their everyday work but need a refresher or have only obtained an introduction to control at university. It is applicable to engineers such as calibration or software engineers that work with control experts. These often need some deeper understanding of the modelling and control methods they are using to ensure successful and efficient implementation.

The course material is motivational to encourage the use of the techniques, rather than dwelling on background mathematics. The hands-on exercises in MATLAB/Simulink software will help engineers understand the modelling and design techniques and can be retained by the attendees. There will be time in coffee and lunch breaks to talk to the instructors about engineers' own problems whether they be concerned with modelling, simulation, control, condition monitoring or problems with implementation.

The first day begins with a presentation motivating the need for improved control methods. This is followed by an introduction to modelling and simulation needed for the analysis and design of control loops. The frequency response analysis methods that are often used, including Bode, Nichols and Nyquist methods, are then considered. The hands-on sessions using MATLAB and Simulink reinforce ideas. For those that are not familiar with these tools, demonstrations are provided.

The second day moves on to design rather than analysis problems and the first presentation emphasizes the importance of feedback control for improving performance, disturbance rejection and reducing the effects of uncertainties. The frequency-domain control design methods are based on the analysis tools described in day one and are introduced. The hands-on sessions provide insights into this type of design process. The importance of control system structures such as feedforward, feedback, cascade and others is then considered, and the improvements in performance are described. The final presentation is on PID controllers. This is of course the most common form of control, and the presentation explains why this control method is so successful and simple to use.

The third day is concerned with more practical aspects including application problems and a look to the future. The important topic of PID controller tuning is covered and a hands-on example provides experience in the methods used. A presentation is included on what makes control engineering difficult. The characteristics of systems that require particular care are noted and the types of solution that should be used are introduced. The problems in implementing controllers are discussed such as PID controller windup and bumpless transfer. Most control loops are now implemented digitally and there is a presentation and hands-on session, on discrete time systems covering topics such as sampling and digital implementation of controllers. The final presentation is on the future directions of industrial control, influenced by developments in AI and Machine Learning that will influence both classical and advanced control designs.

There will be an opportunity throughout the course to interrupt and ask questions or to raise questions at the end of each presentation or during breaks.

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Control Fundamentals Agenda

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Day 1: Linear Systems Models

09.00 Welcome
09.10 L1.1 Introduction and the Need for Improved Control
10.15 L1.2 Fundamentals of Modelling and Simulation
11.00 TEA/COFFEE
11.15 H1.1 Hands-On Session: Modelling for Controller Design using MATLAB/SIMULINK
12.30 LUNCH
13.30 L1.3 Linear Dynamic Systems and Transfer Functions
14.30 TEA/COFFEE
14.45 L1.4 Frequency Response Analysis - Bode, Nichols and Nyquist.
15.45 H1.2 Hands-On Session: Linear System Representations
17.00 CLOSE

Day 2: Classical Control Design

09.00 L2.1 Fundamentals of Feedback Control Design - Performance, Stability and Disturbance Rejection.
10.15 TEA/COFFEE
10.30 H2.1 Hands-On Session: Control Fundamentals
11.30 L2.2 Frequency Domain Control Design - Lead-Lag Compensation
12.30 LUNCH
13.30 H2.2 Hands-On Session: Frequency Domain Control Design
14.30 L2.3 Control System Structures – Feedforward/Feedback Control, Cascade
15.30 TEA/COFFEE
15.45 L2.4 Introduction to PID Controllers – Basics of PID Control
17.00 CLOSE

Day 3 Practical Aspects in Control and Look to the Future

09.00 L3.1 Introduction to PID Controllers - Tuning PID Methods
09.45 H3.1 Hands-On Session: PID Controller Tuning
10.30 TEA/COFFEE
10.45 L3.2 Implementation of Controller Issues - Anti-windup, Bumpless Transfer
11.30 H3.2 Hands-On Session: Practical Aspects in Control
12.30 LUNCH
13.30 L3.3 What Makes Control Difficult – Problems due to Dynamics, Delays, Complexity.
14.15 TEA/COFFEE
14.30 L3.4 Discrete-Time Systems and Control – Continuous to discrete model conversion, sampling, Digital control, Discrete-Time control/filtering methods, Discrete-time PID.
15.45 H3.3 Hands-On Session: Discrete Time Systems Modelling and Control
16.30 L3.5: Look to the Future - Covering New Directions, including Developments in AI and Machine Learning and improvements to both Classical and Advanced Control Methods.
17.00 CLOSE

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