Unit 4016: Instrumentation and Control Systems

Unit Code: T/651/0733

Level: 4

Credits: 15

Introduction

Instrumentation and control can also be described as measurement automation, which is a very important area of engineering. It is responsible for the safe control of a wide range of processes from power stations to manufacturing facilities and even the cruise control in cars.

This unit introduces students to the important principles, components, and practices of instrumentation in controlling of a system, together with the terminology, techniques and components that are used in such a system.

Among the topics included in this unit are: instrumentation systems, instrumentation signal terminology, signal conversion and conditioning, process control systems, process controller terminology, system terminology and concepts, system tuning techniques and application of predicted values to a control system.

On successful completion of this unit students will be able to learn about the measurement of system parameters to a successful process control performance, when and how such measurements are carried out, and developing skills in applying predicted values in order to ensure stability within a control system for a range of input wave forms.

Learning Outcomes

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

LO1 Describe operation of instrumentation devices including parameters used in process control

LO2 Investigate process control systems and controllers

LO3 Analyse the control concepts used within an industrial process

LO4 Apply predicted values to ensure stability within a control system.

Essential Content

LO1 Describe operation of instrumentation devices including parameters used in process control

Instrumentation systems:

Sensors and transducers used in instrumentation including resistive, inductive, capacitive, ultrasonic, pressure, semiconductor, thermocouple and optical

Investigate key design aspects of instrumentation systems using latest industry case studies.

Instrumentation signal terminology:

The importance of instrumentation signal terminology, error, drift, repeatability, including the difference between accuracy and precision, reliability, linearity, sensitivity, resolution, range, and hysteresis.

Signal conversion and conditioning:

Conversion and conditioning of signals, including analogue, digital, optical, microprocessor, wireless and industry standard signal ranges.

LO2 Investigate process control systems and controllers

Process control systems:

The need for process control systems, including quality, safety, consistency, optimisation, efficiency, cost and environmental considerations

Investigate key design aspects of instrumentation systems using latest industry case studies.

Process controller terminology:

Defining set point, process value, output, error, gain, deviation, range, on-off control, two step control and three term control PID (proportional, integral and derivative).

LO3 Analyse the control concepts used within an industrial process

System terminology and concepts:

Recognise system terminology and concepts, including distance velocity lags, capacity, resistance, static and dynamic gain, feedback types, open and closed loop, feed forward control and stability (underdamped, overdamped and critically damped system).

System tuning techniques:

Familiarise with system tuning techniques, including Zeigler-Nichols, continuous cycling, reaction curves, decay methods and overshoot tuning.

LO4 Apply predicted values to ensure stability within a control system

Predicted values:

Investigate block diagram representation of a simplified feedback system (plant and controller) and a closed-loop control system (reference input, controller, plant, feedback, error).

Investigate transfer function representation for a first and second order closed-loop system.

Apply predicted values to a given open and closed loop control system using simulation, to investigate system response to a range of input signal types, evaluate stability of the system using its key parameters (settling time, rise time, peak time, peak value, overshoot, steady state error) and propose possible improvements.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe operation of instrumentation devices including parameters used in process control		
P1 Describe operation of the key types of sensor and transducers used in process control. **P2** Define the signal terminology used in process control. **P3** Explain the different methods and standards used in signal conversion and conditioning.	**M1** Explore industrial applications for sensors and transducers. **M2** Analyse the accuracy of the sensors and transducers used in a particular application.	**D1** Critically review the industrial application of an instrumentation and control process system, using research evidence.
LO2 Investigate process control systems and controllers		
P4 Investigate the importance of process control systems. **P5** Explore the process controller terminology used in industrial applications.	**M3** Analyse a typical industrial application for a process control system.	**D2** Propose recommendations for improvements to process control systems and controllers.
LO3 Analyse the control concepts used within an industrial process		
P6 Examine the control terminology and concepts used in process control systems. **P7** Analyse system tuning methods and techniques employed to improve performance.	**M4** Analyse how the simulated control system responds to a range of signal inputs, in the context of a given industrial process.	**D3** Critically review the reasoning behind system response as different signals are applied, in the context of a given industrial process.
LO4 Apply predicted values to ensure stability within a control system		
P8 Demonstrate the correct use of an instrumentation and control virtual simulation. **P9** Apply tuning techniques in a typical industrial application using simulation.	**M5** Show how the virtual control system responds to a range of signal inputs with technical narrative.	**D4** Argue why the system responds in a certain way as the signals are applied, including stability aspects and possible improvements.

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.

Cappelli M. (2023) *Instrumentation and Control Systems for Nuclear Power Plants*. 1st Ed. Woodhead Publishing.

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.

IEEE Transactions on Instrumentation and Measurement

Journal of Advanced Research in Instrumentation and Control Engineering

Journal of Control and Instrumentation

Journal of Instrumentation

Journal of Process Control

Transactions of the Institute of Measurement and Control