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MODULE SPECIFICATION PROFORMA

Module Title:	**Instrumentation and Control**	**Level**:	5	**Credit Value**:	20

Module code:	ENG52W	**Is this a new module?** Yes	**Code of module being replaced**:	ENG52R

Cost Centre:	GAAE	**JACS3 code**:	H660

Trimester(s) in which to be offered:	1, 2	**With effect from:**	September 18

School:	Faculty of Arts, Science and Technology	**Module Leader:**	Dr Zheng Chen

Scheduled learning and teaching hours	60 hrs
Guided independent study	140 hrs
Placement	0 hrs
Module duration (total hours)	200 hrs

Programme(s) in which to be offered	Core	Option
BEng (Hons) Electrical & Electronic Engineering	✓	☐
BEng (Hons) Automation Engineering	✓	☐

Pre-requisites
None

Office use only
Initial approval February 17
APSC approval of modification September 18 Version 1
Have any derogations received Academic Board approval? Yes ✓ No ☐

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Module Aims
1. To develop methods of obtaining measurements of system variables in an industrial environment and to compare the operation of differing transducers by analysing response time, accuracy, stability and cost. To understand the transduction process and analyse various transducer types; 2. To develop concepts of mathematical modelling in the area of control engineering and to extend established mathematical skills and thus to apply analytical methods to control analysis, system design, implementation and modification; 3. To develop knowledge and skills to plan, manage and conduct control system design with consideration of social, economic and commercial constraints, to conduct the simulation, tuning and testing to evaluate and optimise a continuous control system.

Intended Learning Outcomes

Key skills for employability

KS1	Written, oral and media communication skills
KS2	Leadership, team working and networking skills
KS3	Opportunity, creativity and problem solving skills
KS4	Information technology skills and digital literacy
KS5	Information management skills
KS6	Research skills
KS7	Intercultural and sustainability skills
KS8	Career management skills
KS9	Learning to learn (managing personal and professional development, self-management)
KS10	Numeracy

At the end of this module, students will be able to		Key Skills	
1	Analyse the measurements of an industrial process in terms of the physical quantities which constitute the measured variables; Define the principles of operation of common transducers and match these to the requirements of the measured variables	KS1	KS3
2	Compare the parameters of a range of transducers for a given task (eg the measurement of flow) and hence select an appropriate device; Define and apply the criteria for evaluating the validity of measurements.	KS1	KS3
		KS5	KS10
3	Plan, manage and conduct control system design with consideration of social, economic and commercial constraints	KS1	KS3
		KS5	KS10

4	Understand and use correct mathematical techniques to model and simulate system/process dynamics; conduct detailed practical analyses of continuous control systems.	KS5	KS10
5	Design and/or modify a control system to meet a specified performance in the time domain and through root locus analysis using analytic, graphical, empirical and computer methods	KS1	KS3
		KS5	KS10
6	Design and/or modify a control system to meet a specified performance frequency domain using analytic, graphical, empirical and computer methods and understand the impact of uncertainties to control system design.	KS1	KS3
		KS4	KS10

Transferable/key skills and other attributes

1. Problem solving
2. Mathematical applications
3. Design, analysis and synthesis

Derogations

A derogation from regulations has been approved for this programme which means that whilst the pass mark is 40% overall, each element of assessment (where there is more than one assessment) requires a minimum mark of 30%.

Assessment:

Assessment One: is by means of a portfolio of work, made up of theoretical aspects, research elements and practical results.

Assessment Two: is by means of an examination covering outcomes 4, 5 and 6. It is an unseen time-constrained examination.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)	Duration (if exam)	Word count (or equivalent if appropriate)
1	1,2,3	Portfolio	50		2000
2	4,5,6	Examination	50	2 hrs	

Learning and Teaching Strategies:

The module will be presented to students through lectures, tutorials and practically-based exercises. Approximately one-third of the time will be devoted to practical investigations and will include the use of computer simulation software.

The 'Instrumentation' part will be delivered through lectures supported by pre-written notes, tutorials and laboratory exercises. Practical work will take up approximately 30% of the time allocated to this component. Where possible, industrial visits to observe different process applications will be included.

In 'Continuous Control' the emphasis will be on dynamic system modelling and simulation, and the use of different traditional control system analysis and synthesis approaches for control system design.

Syllabus outline:

Physical Variables: linear and angular displacement, velocity, strain, flow, level, etc.. Selection of appropriate transducers for above with signal conditioners where required.

Errors in measurement systems: Accuracy, precision, hysteresis, zero shift,resolution, linearity, sensitivity. Maximum possible and probable errors. Response and dead time.

Transducers: potentiometers, optical encoders, variable reactance transducers, piezo-electric devices, dc and ac tachogenerators, synchro resolvers.

Comparison of the Measurement Techniques: force, pressure and strain; strain gauges, diaphragm, piezo-electric, Hall effect transducers; analysis of performance parameters of the measurement techniques - for each of the physical variables listed above - in terms of accuracy, resolution, sensitivity and repeatability. Selection of appropriate components for a given measurement system.

Measurement: flow, temperature; optical intensity measurement; proximity detectors.

Control Systems Configuration: Sensors, transducers and actuators; specifications of constituent elements in a control system; electrical, pneumatic and hydraulic actuators; Comparison of pneumatic, electrical and hydraulic systems for various control tasks; Plan, manage and conduct control system design with consideration of social, economic and commercial constraints.

Modelling and Analytical Techniques: System models of physical/electrical systems; open and closed loop systems; similarities of models from different physical systems; differences between servo systems, regulators and process control systems; steady state and transient response; Laplace transform solutions for step, ramp and sinusoidal inputs; final value theorem; transfer functions and characteristic equations; block diagram algebra; poles and zeros; stability; Routh Hurwitz stability criterion; use of computer software for correlation of open and closed loop transient responses.

Time Domain Analysis: Performance criteria – damping ratio, natural frequency, rise time, overshoot, settling time, logarithmic decrement; system lags and time constants; system class and steady state errors for standard input functions; proportional, integral and derivative control empirical methods for determining controller parameters – Zeigler and Nicholls tuning; variations in system response for controller settings.

Frequency Domain Analysis: Bode and Nyquist diagrams; stability criteria; relative stability; gain and phase margins; correlation between frequency response and transient response parameters; derivation of transfer function from Bode diagram; compensation techniques – lag and/or lead networks; design for a specified performance; use of

computer software for control system analyses, syntheses and simulations; Uncertainties in control systems design.

Root Locus Analysis: Closed loop system root loci; Analysis of root locus diagrams; Stability analysis; Compensation design.

Case studies of industrial applications and subject-relevant systems. Selection of appropriate components for a given measurement system.

Bibliography:

Essential reading

Bishop, R.D. and Dorf, R.C. (2013) *Modern Control Systems*, 13th Edn., London: Prentice-Hall.
Bolton W. (2015) *Instrumentation and Control Systems*, Newnes

Other indicative reading

Recommended reading:

Dunn, W.C. (2005) *Fundamentals of Industrial Instrumentation and Process Control*, McGraw-Hill.
Morris, A.S. (2006) *Measurement and Instrumentation Principles*, Butterworth-Heinemann.