



Institiúid Teicneolaíochta Chorcaí
Cork Institute of Technology

INTR8007: Embedded Control Systems

Module Details

Short Title:	Embedded Control Systems APPROVED		
Full Title:	An introduction to embedded control system design		
Module Id:	3545		
Official Code:	INTR8007	NFQ Level:	8
		ECTS Credits:	5

Coordinator:	JOSEPH CONNELL
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Description:	Embedded controlled systems have become ubiquitous in our daily lives, featuring in manufactured systems that vary from digital alarm clocks to automotive engines. The aim of this module is to introduce prospective students to the field of embedded control systems, to provide students with an understanding of digital controller design and evaluation principles, to motivate students to pursue this topic further and to equip students with the necessary skills to design embedded control systems e.g. CAD skills, analysis and design skills, teamwork skills, and the ability to learn independently. The course makes extensive use of CAD software e.g. MATLAB and Simulink and students are required to complete a team-based project.
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Learning Outcomes:

On successful completion of this module the learner will be able to...

1. Apply mathematical tools and theories to analyse closed-loop single-input single-output sampled data systems
2. Design single-input single-output embedded control systems for selected applications
3. Evaluate an embedded control system design in both the time and frequency domain
4. Use computer-aided design tools to simulate, analyse, design and evaluate embedded systems and use ICT tools to communicate results
5. Work effectively as part of a team to research, plan, execute and evaluate an embedded control system design project

Pre-requisite learning

Module Recommendations

This is prior learning (or a practical skill) that is strongly recommended before enrolment in this module. You may enrol in this module if you have not acquired the recommended learning but you will have considerable difficulty in passing (i.e. achieving the learning outcomes of) the module. While the prior learning is expressed as named CIT module(s) it also allows for learning (in another module or modules) which is equivalent to the learning specified in the named module(s).

A course in Engineering Mathematics covering linear systems and transform theory including the Laplace Transform, Z-Transform and Fourier Transform. A first course in control such as Control Fundamentals or equivalent

Incompatible Modules

These are modules which have learning outcomes that are too similar to the learning outcomes of this module. You may not earn additional credit for the same learning and therefore you may not enrol in this module if you have successfully completed any modules in the incompatible list.

No incompatible modules listed

Module Requirements

This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.

No requirements listed



Indicative Content

• Theory

Overview of field of embedded control systems, applications, software/hardware architectures. Sampling, aliasing and design of anti-aliasing filters. Z-Transforms and difference equations. Digital-to-analog converters, analog-to-digital converters and quantisation. Stability of sampled-data systems. Controller design through continuous-time approximations or direct digital synthesis. Practical PID and PID implementations, anti-windup, bumpless control and derivative filtering. Controller evaluation, sensitivity functions, frequency domain analysis

• Simulation

Review of control system toolbox functions such as tf, feedback, step, pzmap, pole. Defining discrete-time functions, sampling continuous-time transfer functions, m-files for programming. Analysing closed-loop sampled data systems in MATLAB. Creating closed-loop sampled-data systems in Simulink. Frequency responses and analysing sensitivity functions.

• Project

The project will be specified at the start of term. Students will work in teams of ~4 to design an embedded system on a micro-processor or micro-controller. The project will contain a research element, planning and organisation, simulation, design, analysis and evaluation. the initial design will be conducted using rapid prototyping tools such as MATLAB+Humusoft or MATLAB+dSPACE and then transferred to PIC or micro-processor. An individual learning log/portfolio will be maintained which may include specified components e.g. review of state-of-the-art, written paper, etc. This will be regularly reviewed and formative + summative feedback will be supplied to the student.

Assessment Breakdown	%
Course Work	100%
End of Semester Formal Examination	0%

Coursework Breakdown				
Type	Description	Outcome addressed	% of total	Assessment Date
Reflective Journal	An individual reflective journal will be produced documenting achievement of learning outcomes	1,2,3,4,5	50	Every Second Week
Open-book Examination	End-of-semester open-book CAD-assisted examination to take place in laboratory	1,2,3,4,5	50	Sem End

The institute reserves the right to alter the nature and timings of assessment



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Module Workload & Resources

Workload		Full-time mode			
Type	Description	Hours	Frequency	Average Weekly Learner Workload	
Lecture	No Description	2	Every Week	2.00	
Lab	No Description	2	Every Week	2.00	
Independent & Directed Learning (Non-contact)	No Description	3	Every Week	3.00	
Total Weekly Learner Workload				7.00	
Total Weekly Contact Hours				4.00	

Workload		Part-time mode			
Type	Description	Hours	Frequency	Average Weekly Learner Workload	
Lecture	No Description	1	Every Week	1.00	
Lab	No Description	2	Every Week	2.00	
Independent & Directed Learning (Non-contact)	No Description	4	Every Week	4.00	
Total Weekly Learner Workload				7.00	

Resources

Supplementary Book Resources

- Gene F. Franklin, J. David Powell, Michael Workman 2006, *Digital Control of Dynamic Systems*, 3rd Edition Ed., Ellis-Kagle Press [ISBN: 978-0979122606]
- J. R. Leigh 2006, *Applied Digital Control: Theory, Design and Implementation*, 2nd Ed., Dover Publications UK [ISBN: 978-0486450513]
- Dogan Ibrahim 2006, *Microcontroller Based Applied Digital Control*, 1st Ed., Wiley [ISBN: 978-0470863350]
- Dimitrios Hristu-Varsakelis (Editor), William S. Levine (Editor), R. Alur (Editor), K.-E. Arzen (Editor), John Baillieul (Editor), T.A. Henzinger (Editor) 2005, *Handbook of Networked and Embedded Control Systems*, 1st Ed., Birkhäuser Boston USA [ISBN: 978-0817632397]

Other Resources

- Website: Prof. Ming Tham, University of Newcastle Upon Tyne 2006, *Control Course Notes and Learning Resources*, Prof. Ming Tham, UK
<http://lorien.ncl.ac.uk/ming/Dept/Swot/connotes.htm>
- Website: 2006 *Design of Embedded Real-time Systems*, Martin Törngren, KTH Zurich
<http://www.md.kth.se/RTC/Derts04/>
- Website: K-E Årzen 2006, *Real-time systems*, Dept. of Automatic Control, Lund Institute of Technology, Sweden
<http://www.control.lth.se/user/FRTN01/material07.html>