Unit T10: Embedded Systems in Engineering

Unit code:	A/503/8619
QCF level:	6
Credit value:	15

Aim

This unit aims to develop learner understanding of embedded systems and the skills to make informed decisions regarding processing elements and hardware within embedded systems.

Unit abstract

This unit explores the challenging fields of modern systems with their increasing demand for applications of complex non-linear processes, an area characterised by the fact that such control systems cannot be specified completely by a standard formal mathematical model. The unit focuses on methods to cope with the increasing complexity of modern systems by developing non-formal methods and specific system architectures which increase the intelligence and flexibility of the system.

Learners will cover methods developed for intelligent control of complex, non-linear processes by incorporating human knowledge and learning. They will also evaluate the design of safe and adaptive controllers to increase the autonomy of systems that operate in unstructured environments.

Learning outcomes

On successful completion of this unit a learner will:

1 understand real-time operating systems in embedded systems

2 understand processing elements used in embedded systems

3 understand how embedded systems communicate with real world signals

4 be able to select and adapt computer architecture for embedded systems

5 understand the application of intelligent control strategies in embedded systems.

Unit content

1 Understand real-time operating systems in embedded systems

Development of embedded systems: historical concept of embedded intelligence; current applications (automotive, still cameras, video cameras, personal communication equipment); future applications

Operating systems used in embedded systems: purpose (memory addressing and management, interrupt and exception handling, process and task management, file system, timing, process scheduling and synchronisation); types (dedicated, single-user–single task, single-user–multitask, multi-user–multitask)

Classification: time constraints (hard real-time systems, soft real-time systems); foreground systems: background systems; defining system characteristics (time-based, sensor-based, interactive systems)

Scheduling protocols: priority based scheduling; deadlock; deadlock recovery; dining philosopher problem

Responses to inputs: generation of interrupt requests by hardware; interrupt service routines and their safeguards; multiple interrupt systems; interrupt identification; interrupt identification servicing; interrupt masking; non-maskable interrupts

2 Understand processing elements used in embedded systems

Microprocessor μP: types of devices available; processor devices' bus and bit structures; additional support integrated circuits; flexibility; uses; advantages; limitations

Microcontroller μC: types of devices available; controller devices' bus and bit structures; additional support integrated circuits; flexibility; uses; advantages; limitations

Peripheral interface controller (PIC): types of devices available; controller devices' bus and bit structures; additional support integrated circuits; flexibility; uses; advantages; limitations

Programmable logic devices (PLD): types of devices available; devices' bus and bit structures; additional support integrated circuits; flexibility; uses; advantages; limitations

3 Understand how embedded systems communicate with real-world signals

Sensors: detection; correct choice of sensor for the measurand being sensed and the range of the measurement; selection; ensuring that the measurand alone is being detected via, eg filtering; signal processing (amplification analogue to digital conversion, linearisation, limiting, filtering); communications; constraints, eg weight, power to weight ratio, volume, cost, environmental requirements, temperature tolerance, spark production, supplies, vibration, reliability

Actuators: physical performance (acceleration, deceleration, velocity, power, load intolerance, degrees of application); operational performance (resolution, accuracy, repeatability); constraints (weight/power to weight ratio, volume, cost, environmental requirements, temperature tolerance, spark production, supplies, vibration, reliability)

Human-machine interface: eg graphical user interfaces (GUI), web-based user interfaces or web user interfaces (WUI), touch screens, command line interfaces, touch user interfaces, attentive user interfaces, gesture interfaces, intelligent user interfaces, motion tracking interfaces, object-oriented user interfaces (OOUI), text user interfaces, voice user interfaces, natural-language interfaces, zero-input interfaces

4 Be able to select and adapt computer architecture for embedded systems

Computer architecture: importance of well-defined architecture; standard Von Neumann architecture; multiprocessor architectures with a shared memory; distributed system architecture

Design methodology: appropriate design methodology (top down, bottom up, structured design, object oriented design, evolutionary design, concurrent design)

Interacting embedded systems: vehicle automation; small measuring instruments with processes; complex digital cameras

5 Understand the application of intelligent control strategies in embedded systems

Machine intelligence: aspects of intelligence (reasoning, problem solving, motion, manipulation, perception, language processing, learning)

Intelligent control methods: fuzzy logic; static knowledge-based systems; artificial neural networks; methodology selection criteria

Adaptive intelligent control: self-diagnostic; self-tune; predictive; dynamic knowledge-based systems; adaptive neural networks

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Understand real-time operating systems in embedded systems	1.1 Critically review the development of embedded systems 1.2 Critically appraise the characteristics of operating systems used in embedded systems 1.3 Classify embedded systems with regard to their operation and scheduling 1.4 Critically evaluate how embedded systems respond to input changes
LO2 Understand processing elements used in embedded system	2.1 Compare processing elements used in embedded systems 2.2 Explain in detail how processing elements are embedded in systems 2.3 Critically evaluate the advantages and limitations of processing elements
LO3 Understand how embedded systems communicate with real world signals	3.1 Summarise the requirements of sensors for different applications 3.2 Summarise the requirements of actuators used in different applications 3.3 Critically evaluate man-machine interface methods used in embedded systems
LO4 Be able to select and adapt computer architecture for embedded systems	4.1 Critically appraise computer architectures for embedded systems 4.2 Justify a chosen design method of computer architectures for a given embedded system 4.3 Critically evaluate interacting embedded systems in typical applications
LO5 Understand the application of intelligent control strategies in embedded systems	5.1 Critically appraise aspects of machine intelligence used in embedded systems 5.2 Justify the selection of intelligent control methods for embedded systems 5.3 Critically appraise adaptive intelligent control techniques systems used in embedded systems.

Guidance

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The learning outcomes associated with this unit are closely linked with:

Level 4	Level 5	Level 6
Unit 22: Programmable Logic Controllers	*Unit 8: Engineering Design*	*Unit T9 Control Engineering Design*
Unit 58: Microprocessor Systems	*Unit 32: Industrial Robot Technology*	
	Unit 40: Knowledge Based Systems and Techniques	

The content of this unit has been designed and mapped against the Engineering Council's current Learning Outcomes for IEng Accreditation. The completion of the learning outcomes for this unit will contribute knowledge, understanding and skills towards the evidence requirements for IEng Registration.

See *Annexe B* for summary of mapping information for IEng Accreditation.

Essential requirements

The use of software packages is an essential part of the teaching of this unit if the centre does not have access to process simulation hardware. Proprietary software such as MATLAB/Simulink, or equivalent, with appropriate tool boxes, will meet the practical requirements.

Delivery

Learning outcome 1 can be taught using articles and by referring to text books as well as reliable web sites.

For Learning outcome 2 it is possible for learners to research different processors and then share findings formally with other members of the cohort. Manufacturers' literature will provide much of the technical information required.

Learning outcome 3 can be taught using articles and by referring to textbooks and reliable websites. Once again manufacturers' literature and can be used where hardware is not available. Software simulation can be used to aid understanding.

For Learning outcome 4 problem-based learning can be used to engage learners. Case studies will provide a valuable resource of different systems with different complexities.

Where possible, Learning outcome 5 should be taught in a practical way with learners using simulation to understand the various control actions.

Assessment

Learning Outcomes 3 and 5 lend themselves to a design type assessment which can be paper based rather than practical. The learner could analyse the stages required to perform the design and to carry out an investigation into the tools available to them. The assignment work will involve a combination of directed and independent learning.

Learning outcomes 1, 2 and 4 should be assessed using a time-constrained activity.

Resources

Books

Ball S R – *Embedded Microprocessor Systems* (Newnes, 2002)
ISBN 978-0750675345

Barr M and Massa A – *Programming Embedded Systems* (O'Reilly, 2006)
ISBN 978-0596009830

Barr M and Massa A – *E-book Programming Embedded Systems*
(O'Reilly, 2009) ISBN 978-0596105518

Arnold K – *Embedded Hardware Controller Design* (LLH Technology Publishing, 2001) ISBN 978-1878707529

Wolf W – Computers as Components: Principles of Embedded Computing Systems Design (Morgan Kaufmann, 2000) ISBN 978-1558605411

Journals

Eurasip – the journal on embedded systems ISSN 16873955, 16873963

Embedded Software Design – the journal of systems architecture
ISSN 1383-7621

Design Automation for Embedded Systems ISSN 0929-5585

Websites

www.seattlerobotics.org	Seattle Robotics Society
www.vault.embedded.com	The official website for the Embedded Development Community
www.ni.com/academic/embedded.htm	National Instruments – Embedded System Design

