Unit 24: Controlling Systems Using IT

Unit code: A/601/7327

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to ensure learners understand the requirements of control systems and control loop operations, know how data is represented in control systems and develop the skills required to design and implement control systems.

Unit introduction

Embedded control systems are appearing in every area of life. They include toys, TV remote controls, many devices with numeric displays and push button inputs such as digital clocks, microwave ovens and heating controllers. In industry, control systems can be found in assembly lines, environmental control, security and CCTV systems. This unit focuses on the techniques typically found in small embedded systems. The unit enables learners to implement control systems in specific scenarios.

Control systems are increasingly found in many manufacturing processes. Although the fundamental principles of control systems have not changed significantly over the years, the increasing sophistication and range of devices has enabled wider application.

This unit considers the actual hardware devices available. Learners will carry out practical activity using control mechanisms to confirm their understanding of theoretical concepts. Developing an understanding of number systems such as binary and hexadecimal as well as logical operators, is essential to the operation of control systems and appropriate content is included.

Learners will spend a significant amount of time in practical workshops developing the necessary knowledge and understanding. Theory will be necessary in order to complete the unit, but this should always be supported by practical demonstrations.

Learners will ultimately design and assemble a control system with different sensors and test it for functionality and performance.

Learning outcomes

On completion of this unit a learner should:

1 Understand the requirements of control systems

2 Know how data is represented in control systems

3 Understand control loop operations

4 Be able to design and implement control systems.

Unit content

1 Understand the requirements of control systems

Types: command systems; programmable systems; sensing systems; conditional systems; examples eg security systems, environmental control, TV remote controls, gate sensors

Digital: microcontroller device selection; basic system design; speed; memory requirements; number of I/O ports needed; digital to analogue (DAC) devices

Analogue: signal conditioning; noise filtering; level-shifting; matching to sensors; analogue to digital (ADC) devices

Sensors: choosing sensors; sensor type eg temperature, light, linear position, shaft position/rotation speed, switch; electrical characteristics of sensors

Output devices: LCD displays; other output devices eg lamps, relays, motors, solenoids; interfacing to controller

2 Know how data is represented in control systems

Coding: eg binary, hexadecimal, binary coded decimal, ASCII

Logical operators: AND; OR; NOT; other eg exclusive OR

Numbers: integer; fixed-point; other eg floating-point; when to use each

3 Understand control loop operations

Control operations: open loop control; closed loop control; feedback; loop stability; proportional-integral-derivative control (PID); proportional control

Sensor signal conditioning: analogue signals sampling; digital filtering

Output: eg pulse wide modulators (PWM), operator displays

Simulation: simulating control system operation; converting the control model

4 Be able to design and implement control systems

Design: purpose; signal type; sensor types; outputs; control operation

Control system implementation: assembly; testing; documentation

Testing: test plan; functional testing; performance testing

Documentation: design; test results; evaluation

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain types of control systems		
P2 explain the characteristics of digital and analogue control systems	**M1** compare analogue and digital signals	
P3 illustrate the operation of different sensors and output devices	**M2** explain the need for signal conversion	
P4 describe how data can be represented in control systems		
P5 explain the stages of control loop operations	**M3** explain the principles and uses of proportional control	
P6 design a control system		**D1** design a control system that uses different types of sensors [CT1]
P7 implement a control system.	**M4** suggest potential improvements to a control system.	**D2** evaluate the design and performance of a control system. [IE4]

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Real-life control systems are very common and learners should be encouraged to investigate them. Laboratory systems or simulations should be based on real-life scenarios. The procedures should be kept simple but include the concepts of feedback and closed-loop control.

It is advised that learners spend a significant amount of time in practical workshops developing some of the knowledge and understanding required at appropriate points where they relate to practical tasks. Theory sessions will be necessary in order to complete the unit, but these should be supported by practical demonstrations.

Lego Dacta and Mind Storms and similar products all offer the software and hardware to be able to deliver this unit.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit
How data is represented in control systems: • whole-class exercise – tutor introduces coding then leads class practical • whole-class exercise – tutor presentation on logical operators • individual exercise – work out tutor-provided integer and fixed point calculation problems.
Requirements of control systems: • directed research – using tutor-provided materials and sources • whole-class exercise – tutor presentation on digital control system requirements, followed by whole-class practical • whole-class exercise – tutor presentation on analogue control system requirements, followed by whole-class practical • whole-class exercise – tutor presentation on sensors, followed by whole-class practical • whole-class exercise – tutor presentation on output devices, followed by whole-class practical.

Topic and suggested assignments/activities and/assessment
Control loop operations: • whole-class exercise – tutor presentation on sensor signal, followed by whole-class practical • whole-class exercise – tutor presentation on conditioning, the following control systems are very common and learners should be encouraged to investigate them. Laboratory systems or simulations should be based on real-life scenarios. The procedures should be kept simple but include the concepts of feedback and closed-loop control • Lego Dacta and Mind Storms and similar products all offer the software and hardware to access this unit • whole-class exercise – tutor presentation on control operations, followed by whole-class practical • whole-class exercise – tutor presentation on outputs, followed by whole-class practical • whole-class exercise – tutor presentation on simulation, followed by whole-class practical.
Assignment 1 – Understanding Control Systems
Implement, test and document a control system: • individual exercise – learners to implement a control system • individual exercise – learners to review implementation.
Assignment 2 – A Working Control System

Assessment

The order of the two suggested assignments may be better if reversed as learners may prefer to relate the theory to their practice. Alternatively, the assignments can be broken down into separate tasks and mixed and matched to reduce the amount of theory covered at once.

Suggested Assignment 1 – Understanding Control Systems

Evidence for this assignment can be presented as a written report, web page, blog, 'wiki', presentation or any other format. Presentations do not need to be formally and verbally given if accompanied by appropriate notes.

For P1, learners must explain all the different types of control systems, as listed in the unit content.

For P2, learners should show that they can explain the characteristics of digital and analogue control systems.

For M1, as an extension of P2, learners must compare analogue and digital signals. The comparison should contain clear understanding of both types of signal, and relate analogue and digital clearly.

For P3, learners should illustrate the operation of different sensors and output devices. This could be carried out as a practical exercise observed by the tutor. In this case, appropriate observation records and supporting documentation will be used as evidence.

P4 is a description of how data can be represented in control systems. Plenty of examples should be included.

For P5, learners need to explain the stages of control loop operations. If the tutor wants to examine this criterion verbally that would be acceptable, however learners might also produce a poster that they could talk the tutor through in a clear and logical way. A question and answer session based around a practical system would also be appropriate.

For M2, learners must explain the need for signal conversion. Learners will be expected to demonstrate clear comprehension of signal conversion theory.

M3 requires an explanation of the principles and uses of proportional control.

Suggested Assignment 2 – A Working Control System

This is the main practical element of the assessment.

For P6 and P7, learners must design and implement a control system. This should be a full working model that demonstrates what the learner has and has not understood from the unit. Logbooks, photos and plans can all be useful evidence, supplemented by test records and witness statements or observation records. The design should include all the elements outlined in the unit content. Testing should include performance testing, ie does it meet its objective efficiently and effectively?

For M4, learners must suggest improvements to their control system following testing.

For D1, learners need to design a control system that uses different types of sensors. 'Different' in this case should be taken to mean the most diverse set possible, less is definitely not more in this case. Evidence could include plans, designs, sketches, presentations, user feedback and written reports.

For D2, learners must evaluate the design and performance of a control system, not necessarily their own. A written report might be most appropriate but alternatives are possible. Whatever the method of evidence chosen, the learner must show they have comprehended control systems to the point where they are capable of making a lucid and well-argued evaluation of the control system.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2,P3, P4, P5, M1, M2, M3	Understanding Control Systems	You have been asked to enter a competition to create a control system by writing a short report showing how well you understand the basics.	Short report or presentation
P6, P7, M4, D1, D2	A Working Control System	You understand it! Now design and implement a control system.	Practical evidence, with a presentation

Links to other BTEC units

This unit forms part of the BTEC in IT sector suite. This unit has particular links with the following unit titles in the IT suite:

Level 1	Level 2	Level 3
		Unit 6: Software Design and Development

Employer engagement and vocational contexts

If you have access to a local manufacturing enterprise learners can be taken to see IT in context, otherwise taking a look at security, environment control or fire management systems is also in the vocational context of this unit.

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	analysing and evaluating the design and performance of a control system, judging its relevance and value
Creative thinkers	generating ideas for the design of a control system that uses different types of sensors, and exploring its possibilities.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Using ICT	
Select, interact with and use ICT systems safely and securely for a complex task in non-routine and unfamiliar contexts	designing and implementing a control system.