Unit 150: Control Systems and Automation

Unit code: R/504/6497
QCF level: 4
Credit value: 15

- **Aim**
  
  The aim of this unit is to give learners an insight into the principles of control engineering and how these principles can be used to model engineering systems and processes.

- **Unit abstract**
  
  This unit will begin by examining analytical techniques that learners will use to form models for engineering systems and processes. Learners will utilise Laplace transforms and Bode standard equations to determine system parameters and gain an understanding of process controllers. The unit will provide a utilisation-focused understanding of control systems and automation.

- **Learning outcomes**

  On successful completion of this unit a learner will:
  
  1. Be able to use analytical techniques to form models of engineering systems and processes
  2. Be able to use Laplace transforms to determine system parameters
  3. Be able to use Bode standard second order equations to determine system parameters
  4. Understand how control parameters are applied to process controllers.
Unit content

1 Be able to use analytical techniques to form models of engineering systems and processes

*Block diagram analysis:* blocks; summing junctions; signal flow; disturbance (MISO systems); canonical reduction; transfer functions

*Nyquist diagrams and Bode plots:* negative feedback; locus of the open loop transfer function; logarithmic plots; magnitude (radius of the polar plot); phase angle; transfer function; analytical techniques (plotting graphs, eg log-linear, circular); parameters (stability, phase, gain, margins)

*Engineering systems, models and processes:* engineering systems (open loop systems and closed loop systems); models (network circuits); processes, eg electric fire, thermostatically controlled heating, steam turbine generators, large antenna positional control system

2 Be able to use Laplace transforms to determine system parameters

*Laplace transforms:* equations with differential and integral terms (‘time domain’ to ‘S-domain’); partial fractions; Laplace transforms of a function; resulting expression; initial conditions; unit, ramp and impulse functions; system parameters first and second order differential equations

*Theory and control systems analysis:* using inverse Laplace transforms to convert S-domain functions to the time domain

3 Be able to use Bode standard second order equations to determine system parameters

*Graphs:* parameters (maximum and successive overshoots, response time, damping ratio); effect on response of varying damping ratio; graphical solution checks, eg maximum overshoot, response time; checking damping factor by calculation, eg Bode standard and second order equations

*Bode standard second order equations:* deriving 1st and 2nd order equations for control systems (gain, natural frequency and damping factor)

4 Understand how control parameters are applied to process controllers

*Process controllers:* control parameters, eg range, span, absolute deviation, control effort, setpoint, bumpless transfer; types, eg proportional control, integral control and derivative control, (PI) Control, (PD) Control, three-term controllers (PID) Control; analysis/evaluation of control systems, eg stability (Zeigler-Nicholls system, reaction wave method)
## Learning outcomes and assessment criteria

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<th>Learning outcomes</th>
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<td><strong>On successful completion of this unit a learner will:</strong></td>
<td><strong>The learner can:</strong></td>
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| LO1 be able to use analytical techniques to form models of engineering systems and processes | 1.1 apply the underlying concepts and principles of block diagram analysis for given engineering systems and processes  
1.2 use analytical techniques to develop a model-based approach for engineering systems and processes |
| LO2 be able to use Laplace transforms to determine system parameters | 2.1 use Laplace transforms to determine system parameters  
2.2 use inverse Laplace transforms to convert S-domain functions to the time domain |
| LO3 be able to use Bode standard second order equations to determine system parameters | 3.1 interpret a graphical solution to verify the maximum overshoot, response time and damping factor  
3.2 check the graphical solution for maximum overshoot, response time and damping factor by calculation  
3.3 use Bode standard second order equations to analyse system parameters |
| LO4 understand how control parameters are applied to process controllers | 4.1 explain how control parameters are used for examining different types of process controllers  
4.2 analyse different types of process controllers for stability |
**Guidance**

**Links**

This unit has links with the following BTEC Higher National units in Engineering:

- Unit 39: Electronic Principles
- Unit 46: Plant and Process Control
- Unit 55: Instrumentation and Control Principles
- Unit 59: Advanced Mathematics for Engineering
- Unit 116: Further Electrical Principles.

**Essential requirements**

Learners will need access to the appropriate mechanical and electrical laboratory equipment.

**Employer engagement and vocational contexts**

Liaison with employers might benefit centres, particularly if employers are able to offer help with the practical application of theory in a workplace context.