ECET 246 Industrial Control Systems

Hours: 3/2.5/0

Prerequisites: ECET 234, ECET 244, ECET 281

Short Description:
Students will study open and closed-loop systems, first and second-order models for system responses, transfer function analysis, stability in control systems, PID controller design, gain and phase margins, and fuzzy control. In addition, they will be introduced to specialized control schemes as used in marine and industrial systems.

Learning Outcomes:
Upon successful completion of this course a student will be able to:

- explain fundamental concepts of control systems, including open closed-loop, feedback, stability, damping, and steady state errors;
- assess the stability of a system;
- evaluate controlled systems in the presence of disturbances;
- apply PID tuning control techniques to industrial systems;
- analyze controlled systems through simulation;
- design a controller in the frequency domain;
- design a fuzzy logic controller for an industrial system;
- explain the differences between analog control and digital control;
- design a control solution for discrete processes

1. Introduction **3 hours**

1.1 Basic concepts
1.2 Definitions of control systems
1.3 General block diagram
1.4 Closed loop and open loop systems and the concept of feedback[1]
1.5 Characteristics of process control systems
1.6 System Gain and Sensitivity

2. System response **6 hours**

2.1 Definition, time and frequency domain concepts
2.2 First-order system analysis
2.3 Second order system analysis
2.4 Overdamped, critically damped and underdamped conditions
2.5 Sallen-Key filter example
2.6 Other examples

3. Transfer function concept in closed loop systems **6 hours**

- 3.1 The feedback loop and transfer function calculation
- 3.2 Review of poles and zeros and stability[2]
- 3.3 Effects of feedback on first order system response
- 3.4 DC motor example
- 3.5 Other examples
- 3.6 Analysis of second order systems in a closed loop
- 3.7 Examples
- 3.8 Steady state output and steady state error
- 3.9 Steady state errors in EXAMPLE systems

4. Stability of general systems **3 hours**

- 4.1 Pole positions
- 4.2 The Routh-Hurwitz test
- 4.3 Root locus analysis

5. Control of continuous processes **6 hours**

- 5.1 On/off vs. continuous controllers
- 5.2 Limitations of a proportional controller
- 5.3 Criteria of good control
  - 5.2.1 The Ziegler-Nichols rules
  - 5.2.3 Quarter amplitude damping (quad) criteria
- 5.4 Proportional/Integral/Derivative controller
- 5.5 Examples

6. Study of servomechanisms **3 hours**

- 6.1 The DC motor in a closed loop system
- 6.2 Disturbances in open and closed-loop systems
- 6.3 Configurations of disturbances in control systems

7. Control of Discrete Processes **3 hours**

- 7.1 Time-driven sequential processes
- 7.2 Event-driven sequential processes
- 7.3 Switching Elements

8. Controls in the frequency domain **3 hours**

- 8.1 Compensation methods
- 8.2 Gain and phase margins
- 8.3 Controller design
- 8.4 The Nyquist criteria

9. Fuzzy Control **3 hours**

- 9.1 Concept of Fuzzy logic
- 9.2 Fuzzification and de-fuzzification examples
- 9.3 Examples

10. Digital Control **2 hours**

10.1 Fundamental of digital processing
10.2 Discrete PID algorithm
10.3 Digital controller

Tests and review	4 hours
Total	**42 hours**

Notes for instructors:

[1] Basic concepts of feedback were introduced in ECET 141 Analog Devices.

[2] Laplace transforms, poles, zeros and stability were studied in ECET 281 System Dynamics.

Labs:

- Introduction to LabView
- System modelling using LabView
- Introduction to Matlab
- Exploration of second-order system response and stability
- Motor speed and position control using analog feedback system
- Implementation of PID control techniques
- Velocity and position control strategies using system modelling
- Process control techniques

Evaluation:

Assignments	10%
Term Tests	30%
Labs	20%
Final Exam	40%

Text:

Optional: Elements of Control Systems by Sudhir Gupta – Prentice Hall