Mechanical Engineering and Mechanics MEM 458 Microcomputer-Based Control Systems I

Course (catalog) description:

DSP microprocessor C programming; data acquisition; microprocessor controller implementation; sensors and actuators; discrete-time systems and the z-transform; sampling rate; the pulse transfer function; time-domain and frequency-domain analysis; digital simulation; introduction to digital controller design. (2-2-3)

Prerequisite(s):

MEM 355 or equivalent

Textbook(s) and/or other required material:

Required Texts: <u>Digital Control System Analysis and Design</u>, by C. L. Phillips and H. T. Nagle, 3rd Edition, Prentice-Hall, 1995.

Reference Texts: Embedded C Programming and the Atmel AVR, by R. Barnett,

L.O'Cull, and S. Cox, Delmar Learning, 2006.

Matlab and Simulink Student Version Release 14 with Service pack 1, The MATH Works Inc., 2005

Course Objectives:

The course aims to provide Mechanical Engineering students in their junior or senior year with the fundamentals of discrete-time control systems. The emphasis is on understanding the analog-to-digital and digital-to-analog conversions, the difference equations, the z-transform, and the analysis of discrete-time control systems. Specific objectives are:

- 1. Understand the advantage of using microcomputer or micro-controller chip in control systems.
- 2. Understand how to model discrete-time systems in the form of difference equations, pulse transfer functions, and discrete state-space representations.
- 3. Understand the z-transform technique and its applications to discrete-time system analysis and design.
- 4. Understand signal sampling, data reconstruction, and analog-to-digital / digital-to-analog conversions.
- 5. Understand the time-domain and frequency-domain analysis of discrete-time systems.
- 6. Understand how to implement a pulse-modulated controller in a micro-controller chip to achieve automatic temperature control.

Topics:

- 1. Embedded C programming
- 2. Data acquisition and processing
- 3. Embedded computer interface
- 4. ADC, DAC, PWM, zero-order hold, optical encoder
- 5. Implementation of digital controllers on the embedded computer
- 6. Discrete-time and sampled-data systems
- 7. Signal sampling and data reconstruction

- 8. The z-transform techniques
- 9. Representations of discrete-time systems
- 10. Time domain analysis and digital simulation

Class/laboratory schedule:

Two hours of lecture per week Two hours laboratory per week

Contribution of course to meeting the Professional Component

The course provides the theoretical fundamentals and hands-on experience of using microcomputer/microprocessor to enhance the performance of mechanical systems.

Relationship to Program Outcomes:

0 = No content; 1 = Some content; 2 = Significant content

Criteria a - k	Cont.	Explanation	Evidence
a. An ability to apply knowledge of mathematics, science and engineering	2	In this course, students learn how to apply digital control theory in the design of microcomputer control systems.	Textbook, Homework, Exams, Handout notes, Lab reports
b. An ability to design and conduct experiments as well as to analyzed and interpret data	2	Students are required to design and implement digital controllers in the lab and observe and analyze the performance of the control system.	Lab reports
c. An ability to design a system, component or process to meet desired needs	2	Students learn how to design a controller to achieve a desired performance.	Textbook, Homework, Exams, Lab reports
d. An ability to function on multidisciplinary teams	2	Three or four students work as a team to use their knowledge in mechanics, electronics, control theory, and computers to achieve the objective of each experiment in this course.	Lab Reports
e. An ability to identify, formulate and solve engineering problems	2	The students are required to formulate and solve control problems based on theory and to verify their results with the experiments.	Exams, Lab reports
f. An understanding of professional and ethical responsibility	1	This is emphasized as part of the design engineer's overall responsibility.	Lab reports
g. An ability to communicate effectively	2	Oral presentation of the experimental procedure and result is required.	Lab reports
h. The broad education necessary to understand the impact of engineering solutions in a global or societal context	1	The impact of engineering design on energy saving, living style, and society is mentioned.	Textbook, Handout notes, Lab reports
i. A recognition of the need for and an ability to engage in lifelong learning	2	Students recognize that lifelong learning is necessary to stay current with the advance of control	Handout notes, Lab reports

		systems design and computer technology.	
j. A knowledge of contemporary issues	2	Design of control systems is related to contemporary issues (energy saving, flight safety, and fighting terrorism, etc.).	Handout notes, Lab reports
k. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice	2	Students use MATLAB, LabVIEW, Simulink, and control systems design packages for design, simulation, experiment implementation, and analysis.	Textbook, Homework, Exams, Handout notes, Lab reports

Prepared by: Dr. B.C. Chang 11/19/2006