ET 438b
Sequential Digital Control and Data Acquisition

Instructor: Dr. Carl Spezia, PE

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Office Hours: 10:00 am - 11:00 am M-W-F
2:00 pm - 3:00 pm M-W-F

           LabVIEW 2009 Student Edition, Robert H. Bishop

Reference: Industrial Controls and Manufacturing, E. W. Kamen

Grading Scale:

- 100-90% A
- 89-80% B
- 79-70% C
- 69-60% D
- 59-below F

Quizzes (6 at 50 points each. One drop score allowed) 45%
Final Exam 20%
Homework 10%
Laboratory Projects/Activities 25%
Total 100%

Course Policies

1. Late Work and Makeup Exams
   No make-up quizzes. All homework is submitted at the beginning of the period it was due. No late homework accepted without prior approval. Late lab grades are reduced by 5% per working day starting from due date.

2. Attendance Policies
   Class attendance is required and attendance will be taken at the beginning of every period. Students are allowed four unexcused absences. Any further absences will reduce the TOTAL grade by 5% per day absent.

Note: the final exam is required for all students in this course. It consists of a national assessment test over the fundamentals of EET. It will be given online during finals week and is scheduled for three hours.
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Course Description and Prerequisites

This course covers the fundamental concepts and components used in computer-based data collection and control systems. The course has two sections: digital data acquisition and sequential control systems. The first part introduces components of a digital measurement system. These components include sensors, signal conditioning, analog-to-digital, and digital-to-analog conversion. Student then use this knowledge to perform measurement and control functions in practical laboratory projects. These projects will require both hardware and software skills. The second section of the course covers staged control processes. Students learn a methodology for designing staged control processes. Relay logic diagrams are covered and used to implement these designs in typical industrial projects. The course introduces the structure and operation of Programmable Logic Controllers (PLCs). The course examines programming and interfacing of external sensor to PLCs. A laboratory demonstrates the lecture topics and gives students experience in programming with a high-level language data collection and control language. Students use simulation software to test the operation of ladder logic designs.

Prerequisite: Engineering Technology 304b and 438a

Course Content Overview

This course is an introduction to digital control systems. Digital control systems can be divided into two categories: digital process control and discrete event control. The mathematical tools used to model and design each of these types of systems are quite different.

In digital process control, the basic structure of the control is similar to analog systems. Sensors measure a process variable and that is fed back to a controller. The controller compares the measured value to an operator-defined value. In analog control, all signals are continuous functions of time. Digital control uses signals that are a series of samples derived from continuous signals.

A digital computer can implement control algorithms that modify the process under control using the obtained series of digital samples. The modification of the sampled signals is called digital signal processing. The first part of this course will focus on acquiring digital signals from an analog process. These inputs may include a number of mechanical and electrical signals, converted into a digital signal, and used to make control decisions for simple on/off or continuous outputs.
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The second part of the course focuses on the hardware and design methodology of discrete event control. In this type of control, discrete tasks take place one after another until a process is completed. An example of this type of control is a washing machine. The design of this class of control system is similar to sequential digital design. These types of systems are implemented using industrially hardened microcomputers called Programmable Logic Controllers, (PLCs). PLCs are programmed using industry standard languages. The simplest type of PLC programming is ladder logic. This language uses the schematic symbols of electromechanical relays to implement the control logic.

These techniques are useful in the analysis and design of a large number of control and data acquisition systems used in industry.

Course Performance Criteria
At the end of this course, you will be able to:
1.) Identify digital control and data acquisition system components
2.) Determine the frequency spectrum of a sampled signal
3.) Determine the bandwidth necessary to accurately reproduce a sampled signal,
4.) Identify aliasing and frequency folding in sampled signals
5.) Identify an on/off controller
6.) Select digital-to-analog converters to meet design specifications
7.) Select analog-to-digital converters to meet design specifications
8.) Design a on/off gap controller using OP AMPS
9.) Interface field devices to a TTL compatible input/output device
10.) Select instrumentation amplifiers for analog signal conditioning
11.) Design and test dc bridge circuits for sensor applications
12.) Write simple programs using LabVIEW software to collect sensor data
13.) Select sensors to measure force, position, velocity, pressure, acceleration, level and temperature
14.) Identify the components of a sequential control system
15.) Read ladder diagrams
16.) Convert ladder logic into digital logic
17.) Design ladder diagrams given a performance specification
18.) Identify the components of a PLC
19.) Develop a PLC program and load it into PLC hardware
20.) Work in teams
21.) Design and test signal conditioning hardware and software in a large project,
22.) Write a large technical report.
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Emergency Procedures

SIUC is committed to providing a safe and healthy environment for study and work. Because some health and safety circumstances are beyond our control, we ask that you become familiar with the SIUC Emergency Response Plan and Building Emergency Response Team (BERT) program. Emergency response information is available on the BERT website at www.bert.siu.edu, Department of Public Safety's website www.dps.siu.edu (disaster drop down) and in the Emergency Response Guidelines pamphlet. Know how to respond to each type of emergency.

Instructors will provide guidance and direction to students in the classroom in the event of an emergency affecting your location. **It is important that you follow these instructions and stay with your instructor during an evacuation or sheltering emergency.** The Building Emergency Response Team will assist your instructor in evacuating the building or sheltering within the facility.

Final Examination Schedule Policy

This course will follow the University schedule for final examinations. The course instructor will not administer the final exam prior to the published University date.

Academic Dishonesty Policy:

Students may be subject to disciplinary proceedings resulting in an academic penalty or disciplinary penalty for academic dishonesty. Academic dishonesty includes, but is not limited to, cheating on a test, plagiarism, or collusion. **References to the Student Conduct Code, (e.g. plagiarism policy).**

ADA Statement for Students Requiring Special Accommodations:

As per Section 504 of the Vocational Rehabilitation Act of 1973 and the American Disabilities Act (ADA) of 1990, if accommodations are needed, inform the instructor as soon as possible.
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Course Outline

Digital Control and Data Collection Overview and Basic Theory
Digital control systems
Computer-based data acquisition and control

Data Flow Programming Languages
LabVIEW programming
Analog input blocks
Computed blocks
Digital I/O blocks

Sampled signal fundamentals
Discrete signal representation and generation
Spectrum representation of signals
Nyquist Sampling Theorem
Aliasing and Folding of sampled signals
Simple digital control-on/off controllers

Digital Signal Conversion and Conditioning
Resolution and accuracy of digital signals
Digital conversion subsystems
Sample and hold circuits
Digital-to-analog conversion
Analog-to-digital conversion
Interface of digital signals

Analog Signal Conditioning
Ideal OP AMP model
Non-linear OP AMP circuits
Voltage comparators
Voltage comparators with hysteresis
Window comparators
Common mode voltages
Difference Amplifiers
Instrumentation Amplifiers
Logarithmic amplifiers
Linearization of signals
Bridge circuits

Class notes and handouts
LabVIEW documentation
Class handouts
Online Tutorials
Section 6.5 Bateson
Class notes and handouts
Appendix C Bateson, pp 643-655.
Class notes and Handouts
Sections 6.2-6.4 Bateson
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General Characteristics of Sensors Sections 5.3-5.5 Bateson
Operating Characteristics
Static Characteristics
Dynamic Characteristics
Selection Criteria

Sensors For Data Acquisition and Control Sections 7.2-7.3 Bateson
Force Measurements
  Strain gages
Position measurement
  potentiometers
  linear variable differential transformers
  synchros
  optical encoders
Velocity Measurements
  Dc tachometers
  Ac tachometers
  Optical tachometers
Temperature Measurement Sections 8.1 Bateson
  Mechanical temperature measurement
  Bimetallic thermostats
  Temperature transducers
  Resistance Temperature Devices
  Thermocouples
  IC temperature sensors
Pressure Measurement Section 8.3 Bateson
  Strain gages
  Deflection types
Level measurements
Acceleration Measurement

Discrete Event Control Systems Sections 9.1-9.3 Bateson
Introduction to Programmable logic controller hardware
  Input and output devices for PLCs
  Ladder logic introduction
Designing discrete event control Chapter 11 Bateson
  state-transition techniques
  ladder logic implementation
  ladder logic simulation software
Chapter 12 Bateson
Assessment Review

National Assessment
Exam (comprehensive)
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Course Outline

**Quiz Schedule**
Quizzes are scheduled after approximately 6 lecture periods. They will take between 30-40 minutes. Schedule is subject to change.

<table>
<thead>
<tr>
<th>Quiz</th>
<th>Date</th>
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<tbody>
<tr>
<td>Quiz 1</td>
<td>Friday, January 31, 2014</td>
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<tr>
<td>Quiz 2</td>
<td>Monday, February 17, 2014</td>
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<tr>
<td>Quiz 3</td>
<td>Wednesday, March 5, 2014</td>
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<tr>
<td>Quiz 4</td>
<td>Monday, March 31, 2014</td>
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<tr>
<td>Quiz 5</td>
<td>Wednesday, April 16, 2014</td>
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<tr>
<td>Quiz 6</td>
<td>Friday, May 2, 2014</td>
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</tbody>
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Homework Assignments

1. 6.31
2. amhw.wp5, specan.wp5
3. P2.3, P2.4
4. 6.32, P2.8
5. 6.33, dachw2.wp5, dac_hw1.wp5
6. 6.34, P5.5
7. bonus3.wp5
8. diohw1.wp5
9. mask.wp5, P6.2
10. slew.wp5, labvhw.wp5
11. gaphw.wp5, 6.4 6.5
12. window.wp5
13. differ.wp5, diffsen.wp5
14. 6-22***, 5-5, 5-7, 5-19
15. 7.1, 7.2, 7.3, 7.4
16. 7-17, D8.3, D9.3
17. 7.20
18. seqhw38.wp5
19. ladder.wp5
20. xorlad.wp5
21. lad2log.wp5, log2lad.wp5
22. addrplc.wp5
23. plcpgm1.wp5
24. TBA

*Note: all homework assignments with this format are from handout packet. This list is subject to change during the course of the semester.
***Use Resistance range of 149-151 ohms from 6-21
1.) Automated Testing Project (10 weeks)

Build a automatic tester that will measure and plot the frequency response of a two-stage amplifier circuit using a data acquisition board and high-level software. Additional hardware is designed and constructed to allow a computer to control the output frequency of a sine wave oscillator that is connected to the input of the amplifier. Other circuits convert the input voltages, output voltages, and test frequency to levels that are compatible with the computer hardware. A computer program logs the data, calculates the gain in decibels, and displays the results.

2.) Programming Ladder Logic on a Programmable Logic Controller (5 weeks)

Short PLC programming exercises familiarize users with the programming software and instruction sets of Programmable Logic Controllers (PLCs) typically found in industry.
Syllabus Attachment
Spring 2014

MARRIOTT S. KING, JR.'S BIRTHDAY 01/20/2014
Spring Vacation 03/08—03/16/2014
WITHDRAWAL POLICY—Undergraduate only
Students who officially register for a session may not withdraw merely by the
stopping of attendance. An official withdrawal form needs to be initiated by the
student and processed by the University. For the proper procedures to follow
when dropping courses and when withdrawing from the University, please visit
INCOMPLETE POLICY—Undergraduate only
An INC is assigned when, for reasons beyond their control, students engaged in
passing work are unable to complete all class assignments. An INC must be
changed to a completed grade within one semester following the term in which the
course was taken, or graduation, whichever occurs first. Should the student
fail to complete the course within the time period designated, that is, by no
later than the end of the semester following the term in which the course was
taken, or graduation, whichever occurs first, the incomplete will be converted to
a grade of F and the grade will be computed in the student's grade point
average. For more information please visit:
http://registrar.siu.edu/grades/incomplete.html
REPEAT POLICY
An undergraduate student may, for the purpose of raising a grade, enroll in a
course for credit no more than two times (two total enrollments) unless
otherwise noted in the course description. For students receiving a letter grade
of A, B, C, D, or F, the course repetition must occur at Southern Illinois
University Carbondale. Only the most recent (last) grade will be calculated in
the overall GPA and count toward hours earned. See full policy at
GRADUATE POLICIES
Graduate policies often vary from Undergraduate policies. To view the
applicable policies for graduate students, please visit
DISABILITY POLICY
Disability Support Services provides the required academic and programmatic
support services to students with permanent and temporary disabilities. DSS
provides centralized coordination and referral services. To utilize DSS
services, students must come to the DSS to open cases. The process involves
interviews, reviews of student-supplied documentation, and completion of
Disability Accommodation Agreements.
http://disabilityservices.siu.edu/
STUDENT CONDUCT CODE
http://policies.siu.edu/policies/students/student_conduct.html

SALUKI CARES
The purpose of Saluki Cares is to develop, facilitate and coordinate a
university-wide program of care and support for students in any type of
distress—physical, emotional, financial, or personal. By working
closely with faculty, staff, students and their families, SIU will continue to
display a culture of care and demonstrate to our students and their
families that they are an important part of the community. For
Information on Saluki Cares: (618) 453-5714, or salukicares@siu.edu,
http://salukicares.siu.edu/index.html

EMERGENCY PROCEDURES
Southern Illinois University Carbondale is committed to providing a
safe and healthy environment for study and work. We ask that you
become familiar with the SIU Emergency Response Plan and Building
Emergency Response Team (BERT) programs. Emergency response
information is available on posters in buildings on campus, available on BERT’s website at www.bert.siu.edu, Department of
Safety’s website at www.mps.siu.edu (disaster drop down) and the
Emergency Response Guideline pamphlet. Instructors will provide
guidance and direction to students in the classroom in the event of an
emergency affecting your location. It is important that you follow these
instructions and stay with your instructor during an evacuation or
sheltering emergency.

INCLUSIVE EXCELLENCE
SIU contains people from all walks of life from many different
cultures and sub-cultures and representing all strata of society,
nationalities, ethnicities, lifestyles, and affiliations. Learning from and
working with people who differ is an important part of education as well
an essential preparation for any career. For more information please
visit: http://www.inclusiveexcellence.siu.edu/

MORRIS LIBRARY HOURS
http://www.lib.siu.edu/about

LEARNING AND SUPPORT SERVICES
Help is within reach. Learning support services offers free tutoring on
campus and math labs. To find more information please visit the Center
for Learning and Support Services website:
Tutoring: http://tutoring.siu.edu/
Math Labs http://tutoring.siu.edu/math_tutoring/index.html

WRITING CENTER
The Writing Center offers free tutoring services to all SIU students and
faculty. To find a Center or Schedule an appointment please visit
http://write.siu.edu/

AFFIRMATIVE ACTION & EQUAL OPPORTUNITY
Our office's main focus is to ensure that the university complies with
federal and state equity policies and handles reporting and investigating
discrimination cases. For more information visit:
http://diversity.siu.edu/

Additional Resources Available:
SALUKINET: https://salukinet.siu.edu/cgi/home/displaylogi
ADVISEMENT: http://advisement.siu.edu/
PROVOST & VICE CHANCELLOR: http://provost.siu.edu/
SIU ONLINE: http://online.siu.edu/

^ Southern Illinois University Carbondale. (2013). Pathways to Excellence: A Strategic Plan
Retrieved from http://siostrategy.siu.edu/