EEE 481 Computer-Controlled Systems (4) [S]

Course (Catalogue) Description:
Implementation of computer-based, embedded, control systems using MATLAB xPC Target toolbox. Small-scale, representative projects demonstrate theoretical issues and provide hands-on expertise. Students enrolled in the graduate EEE591 section will also undertake a controller design project with hardware implementation on an Arduino platform, or equivalent.
Lecture, Lab. Technical Elective.

Prerequisite:
EEE 203 and 230 (or CSE 230). Or, MAE 318 only

Textbook: C.L. Phillips, T. Nagle, A. Chakrabortty, Digital Control System Analysis & Design (4th Edition), Prentice Hall, 2014.

Supplemental Materials:
Class notes and software distributed by the instructor.

Coordinator:
K. Tsakalis

Course Objectives:
1. Students are familiar with the most common elements of computer control: sensors, sampling, control algorithms, actuators.
2. Students understand the basic problems in computer control of processes: principles of feedback and feedforward control, sampling, quantization, real-time operation.
3. Students are familiar with computer software to implement embedded control systems (e.g., MATLAB, Real-Time Workshop, xPC Target).

Course Outcomes:
1. Students can discuss the principles of operation of common sensors and actuators,
2. Students can state and apply basic definitions in measurements. A/D-D/A converters.
3. Students can apply standard design techniques for common control algorithms (PID, FF).
4. Students can discuss and analyze issues related to controller discretization and signal/parameter quantization.
5. Students can use computer software to implement embedded controllers.

Course Topics:
1. *Examples of computer controlled systems:* Position, Velocity, Voltage, Current, Power cntrl.
2. *Instrumentation*:* Accuracy, Precision, Resolution. Electrical Measurements. Bridge circuits. Thermocouples, Thermistors. Strain gauges. Optical sensors. Counters, Trigger circuits.
3. *Real-Time and Discretization Issues:* Real-time operating systems, Interrupts. Discretization errors, Sampling and reconstruction. Anti-aliasing filters. Quantization.
4. *Software and Hardware Platforms:* MATLAB/SIMULINK Real-Time Workshop, Auto-code generation. The PC104 platform. Microcontrollers (Arduino). Digital communications.
5. *Actuators*:* Electrical, Pneumatic, actuators. Solenoids, Relays. SCRs, TRIACs. Motors.

6. *Control Algorithms and Procedures:* Sampled-data control. Dynamical Systems descriptions, state-space concepts, discretization. Feedforward controllers, dynamic inversion. Feedback Systems: Basic Properties, Stability, Sensitivity. PID control principles. Discrete-time implementations, quick tuning procedures.

Computer Usage: Exercises and demonstrations using MATLAB/SIMULINK.

Laboratory Experiments:
1. Familiarization with basic hardware connections and procedures to create real-time executables. Target-Host communications and MATLAB programming.
2. RS-232 serial port asynchronous communication. Arduino family microcontroller boards and I2C, SPI communications
3. A/D-D/A converters, Sampling and Reconstruction.
4. Modeling and implementation of a virtual heat transfer experiment; PID control.
5. Modeling and implementation of a virtual water level control experiment.
6. Modeling and implementation of a virtual inverted pendulum experiment; more complicated controller design and communication requirements.

Assessment: Through homeworks, quizzes, tests, laboratory/project and final exam.

Course Contribution to Engineering Science and Design:
EEE 481 focuses on engineering design by using open-ended exercises and hardware/software implementation of theoretically derived algorithms. Emphasis is placed on integrating verious components. Since there are many possible solutions to such a problem, students are able to consider design tradeoffs and issues involved in practical implementation.

Course Relationship to Program Outcomes:
Relates to outcomes a,c,e,h,k:
The operation of basic sensor and actuators, analog-to-digital and digital-to-analog conversions,and common computer communication protocols and platforms, are reviewed to enable their usage in control system implementations. This provides a broad perspective on the applications of feedback systems (**h**). Students learn the advantages and limitations of various hardware and software components of control systems. They are using this knowledge to provide integrated control system solutions for virtual properties (**c**). Students obtain models for various processes and create virtual (computer simulated) experiments, for which they then design control systems (**e**). The translation of physical problems into an abstract but rigorous and quantitative mathematical framework enhances the understanding of the physical phenomena (**a**). The creation of virtual experiments also requires a deeper understanding of model limitations. Students are exposed to modern computational techniques for designing feedback and feedforward control systems. They are also exposed to modern CAD tools (e.g., MATLAB, RTW) that have been used extensively in industry and academia for modeling and implementation of control systems (**k**).

Person preparing this description and date of preparation: K. Tsakalis, June 2015.