AeroE/EE/Math/ME 576: Digital Control

http://www.ece.iastate.edu/~rkumar/EE576

Instructor

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Text: Digital Control System Analysis and Design, C. L. Phillips, T. Nagle and A. Chakrabortty, Prentice Hall, 4th Edition, 2015.

Supplementary: Digital Control of Dynamic Systems, G. F. Franklin, J. D. Powell and M. Workman, Ellis-Kagel Press, 3rd Edition, 1997.

Course Description:

- Introduction (Chapter 1)
- Discrete-time System (Chapter 2)
- Sampling and Reconstruction (Chapter 3)
- Open-loop Discrete-time System (Chapter 4)
- Closed-loop Discrete-time Systems (Chapter 5)
- System Specifications (Chapter 6)
- Stability Analysis (Chapter 7)
- Classical Digital Control Design (Chapter 8)
- State Space Design (Chapter 9)
- System Identification (Chapter 10)
- Linear Quadratic Optimal Control (Chapter 11)
- Case Studies (Chapter 12, time permitted)

Grading Scheme:

- Home works will be assigned on a weekly basis. They will be due a week later. Prior arrangements must be made for a possible late submission. The TA will grade the home works, so please contact your TA for questions regarding your home work grades.
- There will 2 midterms; the dates will be announced later in the class. Make-up exams will be given only for unanticipated events (medical, emergency travel, etc.); adequate documentation must be provided, and possibly in advance.
- Each student will do a project which will involve selecting a practical discrete-time system and per-forming its complete analysis (for example as covered in the textbook). A project report describing the system and its analysis will be due on the day of the nals, and each student will make a brief (20-25min) in-class presentation of his/her project. The order of presentation will be the alphabetical ordering of the last names.

The overall distribution of grades is obtained as:

Home works:	25%
Project:	25%
Exams:	50%
Total:	100%

Final letter grade will be assigned based on class score distribution, and at least 50% is required to pass the course.

Note on Free Expression: Iowa State University supports and upholds the First Amendment protection of freedom of speech and the principle of academic freedom in order to foster a learning environment where open inquiry and the vigorous debate of a diversity of ideas are encouraged. Students will not be penalized for the content or viewpoints of their speech as long as student expression in a class context is germane to the subject matter of the class and conveyed in an appropriate manner.

Note on Disability Accommodations: If you have a disability and require accommodations, please contact the instructor early in the semester so that your learning needs may be appropriately met. You will need to provide documentation of your disability to the Disability Resources (DR) office, located on the main floor of the Student Services Building, Room 1076, 515-294-7220.

Learning Objectives:

- Learn system modeling and analysis in continuous-time for physical plants: both input/output domain and state-space models; in time-domain and in s-domain
- Learn system modeling and analysis in discrete-time for digital controllers: both input/output domain and state-space models; in time-domain and in z-domain
- Learn modeling and analysis of continuous-to-discrete interface in form of Sampler: computation of z-transform of sampled signal from s-transform of unsampled signal; use of residue based computation; learn frequency spectrum of sample vs unsampled signal, and how importance of Nyquist sampling rate viz-a-viz reconstruction
- Learn modeling and analysis of discrete-to-continuous interface in form of data-holding devices: their transfer functions and frequency responses to see their low-pass ltering nature to understand their reconstruction capabilities from sampled signals
- Learn modeling and analysis of sample-data control systems that include continuous-time plant, discrete-time controller, discrete-to-continuous interface in form of data-hold, and continuous-to-discrete inter-face in form of sampler; computation of Pulse Transfer Function as well as zero-order-hold based state-space discretization
- Learn the control-speci cation in terms of stability and their margins, tracking, disturbance and noise rejection, robustness, transient and steady-state responses, and control bandwidths, and relationship of some of those to s-domain and z-domain poles, system type number etc.
- Learn stability analysis tools based on Routh-Hurwitz and Jury tests, Nyquist plot and Root-locus plot
- Learn zero-order control design using Root-locus
- Learn 1st-order control design using phase-lag and phase-lead architectures
- Learn 2nd-order control design using cascade of phase-lag and phase-lead architectures, and PID architecture
- Learn nth-order control design using pole-placement methods of state-space, and controllability and observability requirements
- Learn nth-order and reduced-order observer designs; the predictor-corrector observer form, and its extension to noisy setting in form of Kalman filtering that is designed to minimize effect of noise in state estimation
- Learn methods to identify system model through input-output observations in form of parametric estimation
- Learn methods for optimal control design and robust control optimization
- Learn selecting of sampling rate, and effect of finite-word precision on error bounds