Course Syllabus

EE543 Digital Control Systems
EE-Systems, University of Southern California
Spring Semester, 2020

Control systems are the invisible threads of human technology for thousands of years. The invention of microprocessor has revolutionized control system technology to a much more advanced level since 1980’s. Today over 100 million digital controllers have been implemented throughout the world. Human control systems controlled by digital computers have equipped with software coded high precision and high performed complex control laws to fulfill magnificent tasks on this planet and beyond.

EE543 is a unique control course that teaches the fundamental theory and tools applying to model, analyze and design this fascinating digital control system technology.

COURSE MATERIALS

Textbook, *Digital Control System, Analysis and Design*, 3rd ed, by Charles L. Phillips and H. Troy Nagel, 1955. Lecture notes power point pdf files, MATLAB tools and published papers where applicable.

LECTURER

Richard Y. Chiang, PhD, Aerospace Sr. Specialist and ex-Boeing Technical Fellow, Boeing Satellite Development Center, El Segundo, California. Dr. Chiang is a nationally and internationally recognized expert in robust control system design and system identification. He is the leading author on the MATLAB software, Robust Control Toolbox, of which more than 30,000 copies have been sold worldwide across industries and academia for the last 30 years. His control design methodology has become a universal standard in the field.

Dr. Chiang began his career 30 years ago as a control system analyst at Garrett AiResearch. During the 1990s, he also worked for Northrop Aircraft on F-18 supermaneuver flight control and at JPL on large space structure vibration control. Since joining Boeing in the late '90s, he has designed attitude control systems for 15 satellites and analyzed system stability for 20 programs. He has taught senior control courses at USC and has given control seminars at DEC, Northrop, General Dynamics, and JPL in the 1990s and several at Boeing from 2002 to the present. He also has published 17 journal papers and 50+ conference papers, and has 10 issued U.S. patents and five patent applications pending related to digital spacecraft control system design.

COURSE OUTLINE

- Big picture of a control system
  —What is a control system?
  —Control design objectives (why are we doing this?)
  —Brief history of classical/modern control theory
  ---Modeling a control system
- Why “digital” control
- Digital Control Basics
  — Z-transform
  — Inverse Z-transform
  — Starred transform
- Modeling a Digital Control System
  — Digital filters
  — Discrete state-space realization and solution
  — Ideal sampler
  — Sampling Theorem, Nyquist Frequency
  — Hold Equivalences (ZOH, FOH, TOH)
  — Bilinear transform in analysis and design
  — W-plane
  — Modeling multi-rate sampled-data systems
  — Delta operator
- Analysis of Digital Control System
  — Stability
  — Digital root locus
  — Digital frequency response
- Design of a Digital Control System
  — Design objectives
  — Design procedures
  — Design specifications
  — Types of compensators
  — SISO design (root locus, Bode response)
  — MIMO state-space pole-placement and observer
  — MIMO optimal LQ, Kalman Filters
- Digital control design project for a two-mass-spring benchmark problem
- Advanced Topics
  --- Digital simulation
  --- Digital control real world applications
  --- Dynamic System Identification

For more information call instructor Richard Y. Chiang at 310-951-0382 (cell).