

# Course Syllabus

**EE543 Digital Control Systems**  
**EE-Systems, University of Southern California**  
Spring Semester, 2025  
**Dr. Richard Y. Chiang ([chiangr@usc.edu](mailto:chiangr@usc.edu))**

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 with 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. It is considered Part II of the EE482 Linear Control System (continuous domain). These two courses (EE482 & EE543) which have solved 90% of the real world control problems are the most important courses to build your control career upon.

## COURSE MATERIALS

Textbook, *Digital Control System, Analysis and Design*, 4th ed, by Charles L. Phillips and H. Troy Nagel, 2015. Lecture notes power point pdf files, MATLAB tools and published papers where applicable.

## LECTURER

**Richard Y. Chiang**, PhD, Sr. Specialist, Control Analysis Department, Aerospace Corp, El Segundo, California, 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 50,000 copies have been sold worldwide across industries and academia for the last 30 years. His multivariable control design methodology has become the universal standard in the field.

Dr. Chiang began his career 40 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 (EE 482, EE 543) 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. During 2004~2019, he also taught several short courses on Robust Control, Spacecraft Dynamics, Control and Estimation at UCLA Extension. Dr. Chiang 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
- Analysis of Digital Control System
  - Stability
  - Digital root locus
  - Digital frequency response
- Design of a Digital Control System
  - Design objectives, procedures and specifications
  - Types of compensators
  - SISO design (root locus, Bode response)
  - MIMO state-space pole-placement and observer
  - MIMO optimal LQ, Kalman Filters
- Advanced Topics
  - Digital simulation
  - Delta operator
  - Multi-rate sampling
  - Digital control with finite precision arithmetic
  - Discrete PSD and Dynamic System Identification
- **Course Requirements: Regular Homework, Mid-Term and Final.** In addition, a **Digital control design project** for a two-mass-spring benchmark problem is required to be presented at the end of the semester. The design package has been served as a perfect job interview presentation for the past students since 2015.

For more information, call Dr. Chiang at 310-951-0382 (cell) or Email: [chiangr@usc.edu](mailto:chiangr@usc.edu).