Introduction to Control Systems

August 2023 Version

Resources:

- N.S. Nise, Control System Engineering, Seventh Ed. Wiley 2015
- Katsuhiko Ogata, Modern Control Engineering, 5th Edition.

Course Description

Fundamentals of classical control analysis and design. Topics include modeling and analyzing control systems, the design of automatic controllers.

Part 1: Modeling and Analyzing Control Systems

Week 1. Intro Control Engineering: Constructing Block Diagrams, System Components (plant, actuator, sensor, controller), Determining how different components are connected.

Resources:

Nise Chapter 1,
Ogata, Chapter 1

Week 1. Review on Dynamics 2: Laplace Transform, Inverse Laplace Transform, Partial Fraction Expansion, Dynamic Models of the first-order and second-order systems,

Resources:

Nise Chapters 2 and 4,
Ogata, Chapters 2 and 5

Week 2. Modeling in Frequency Domain: Intro to Transfer Functions, Deriving Transfer Function from Differential Equation for SISO and MIMO systems, Poles and Zeros in Transfer Function, Multivariable and Interconnected Systems: Reducing Interconnected systems, Mason's

Resources:

Nise Chapters 2 and 5,
Ogata, Chapters 2, 3, 5

Week 3. Modeling in Time Domain: Intro to State Space Representation, Deriving State-space representation from equations of motion, Deriving Transfer functions from SSR.

Resources:

Nise Chapter 3,
Ogata, Chapter 9

Week 4: Stability Analysis: Stability Analysis using Transfer Function, Routh Hurwitz, Stability Analysis using SSR Eigenvalues, BIBo stability and Internal Stability

Resources:

Nise Chapter 6 and 7,
Ogata, Chapters 5

Week 5. Linearization: linearization of static single and multi-variable function, linearization of SSR for SISO and MIMO systems.

Resources:

Ogata, Chapters 2

Part2: Design of Automatic Controllers

Weeks 6 to 8. Root Locus- Based Control Design: Basic Rules of Root Locus, Designing Basic Controllers such as P, P-FF, PI, PID, and Lead-Lag Controllers

Resources:

Nise Chapters 8-11,
Ogata, Chapters 6-7

Week 9 Multi-Loop Controllers: Inner Loop/Outer Loop Design Techniques: Sequential Loop Closure, Parallel Design w/ Assumed t-Scale Separation, Parallel Design w/ Approx. Closed Inner Loop

Resources:

Nise Chapters 8-11,

Weeks 11 to 13. Control System Analysis and by Bode Plots: Bode Plots Rules, Loop Shaping, Stability Margins in Bode plots, Communication Delays, Uncertain Systems, Designing Basic Controllers such as P, P-FF, PI, PID, and Lead-Lag Controllers

Resources:

Nise Chapters 8-11,
Ogata, Chapters 7-11

Week 14. Control System Design in State Space: State-Feedback Control Design: Controllability Definition, Tracking with State Feedback, Integral Control

Resources:

Nise Chapter 12,
Ogata, Chapter 10

Week 15. Observer-Based Control Design: Observability and Detectability Definitions, Observer Design, Observations with Unmeasured Disturbance and Noise

Resources:

Ogata, Chapter 10