Lecture1:Course Overview and Introduction

ELG 3155 : Introduction to Control Systems

❑Objective:

- Syllabus.
- Course Introduction & rules.

Hitham Jleed

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Office Hours: TBO

Schedule: (   )

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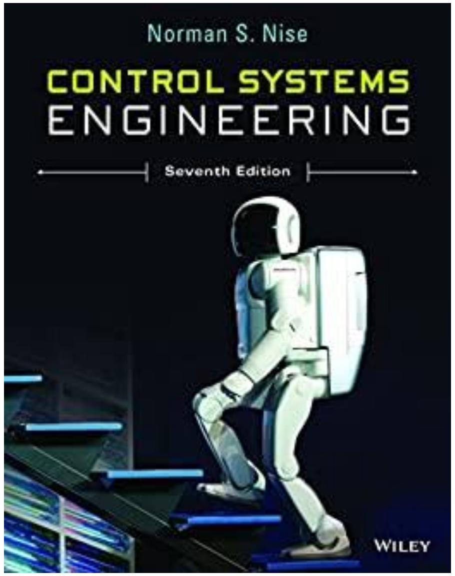
Schedule

TEXTBOOK



Nise, Norman S. **Control systems engineering**. 7th edition, John Wiley & Sons, 2015., ISBN: 978-1-118-80063-8

Student Companion Site (Free) [html] Nise: Control Systems Engineering, 7th Edition - Student Companion Site (wiley.com)

RECOMMENDED TEXTS/MATERIALS

- K. Ogata, Modern Control Engineering, 5th (or any other edition), Prentice Hall.
- C.D. Dorf and R.H. Bishop, Modern Control Systems, 11th Ed. (or any other edition), Prentice Hall

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COURSE LECTURE NOTES

CALENDAR DESCRIPTION

Introduction to control systems, dynamic systems modeling. Laplace transforms, partial fraction methods. Block diagram and signal flow graph models, transfer functions of linear systems. Introduction to state-space models. Feedback control system characteristics, stability and Routh-Hurwitz criteria, the root locus method, design of industrial controllers, the Nyquist stability criterion, Bode plots, design indexes, lead and lag controllers.

COURSE OBJECTIVES

At the end of the course, you are aimed to be able to:

- Build mathematical models of basic electrical systems and based on these models, have a solid understanding of how to build mathematical models of more complex systems.
- Design basic types of controllers, including P, PI, PID controllers for typical electrical systems.
- Identify dynamic electrical systems, that is build mathematical models and identify the values of the parameters of these models based on experimental input-output measurements.
- Have a good background for studying more advanced controls and control application topics, such as robust control, nonlinear control, adaptive control, robotic control, vehicle stability control, aerospace control, etc.

COURSE COMPONENT: Laboratory, Lecture, and Tutorial.

Course Outline (1)

1. Introduction to control systems
   - Design analysis and objectives
   - Design process

2. Modeling in the frequency domain
   - Laplace transform review
   - Transfer function
   - Electrical network transfer function
   - Mechanical systems transfer function

Course Outline (2)

3. Modeling in the time domain
   - General state space representation
   - Applying the state space representation
   - Conversion of transfer function to state space
   - Conversion of state space to transfer function
4. Time response
   - Poles, zeros, and system response
   - First-order systems
   - Second-order systems (general form)
   - Underdamped second-order systems
   - System response with additional poles
   - System response with additional zeros
   - Laplace transform solution of state equations
   - Time domain solution of state equations

Course Outline (3)

5. Reduction of multiple subsystems
   - Block diagrams
   - Analysis and design of feedback systems
   - Signal flow graphs
   - Mason's rule
   - Signal flow graphs of state equations
   - Alternative representations in state space
6. Stability
   - Routh-Hurwitz criterion
   - Stability in state space

Course Outline (4)

7. Steady-state errors
   – Steady-state error for unity feedback systems
   – Static error constants and system type
   – Steady-state error for disturbances
   – Steady-state error for non-unity feedback systems
8. Root locus techniques
   – Properties of the root locus
   – Sketching the root locus
   – Root locus for positive feedback systems

Course Outline (5)

9. Design via root locus
   - Improving steady-state error via cascade compensation (PI, phase lag)
   - Improving transient response via cascade compensation (PD, phase lead)
   - Improving steady-state error and transient response via cascade compensation (PID, lead-lag)
   - Physical realization of compensation
10. Frequency response techniques
    - Asymptotic approximation: Bode plots
    - Introduction to the Nyquist criterion
    - Sketching the Nyquist diagram
    - Stability via the Nyquist diagram
    - Gain margin and phase margin via the Nyquist diagram
    - Stability, gain margin, and phase margin via Bode plots

COURSE OUTLINE (VISUALIZATION)

- Overall Approach

Modeling → Analysis → Design → Implement

- System Modeling:
  - Describe the relationship between the system's input(s) and output(s).

Modeling

Other LTI system model types ?

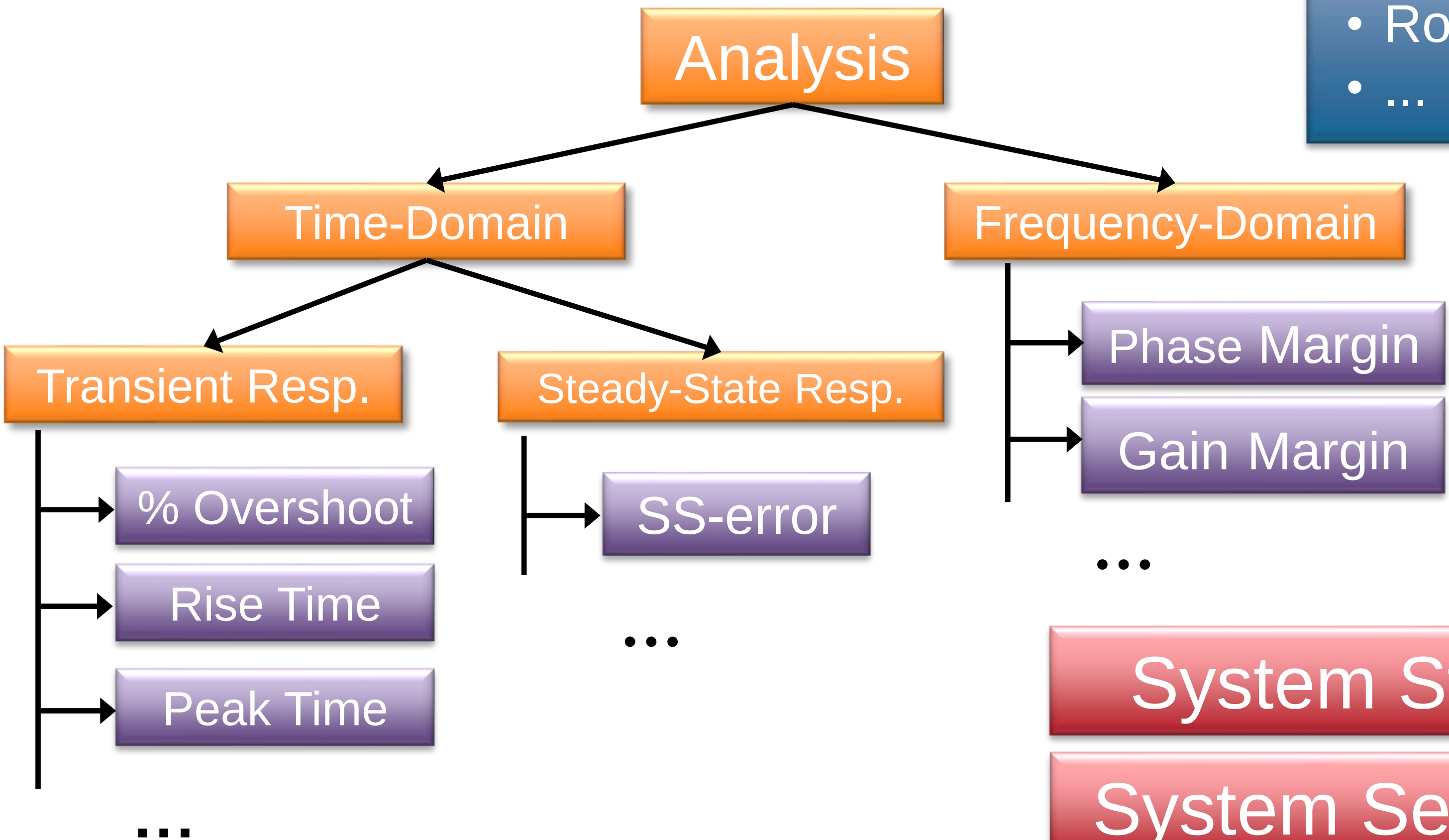
ODE | Transfer Function | Block Diagram | State-Space Representation

System Types: Electrical, mechanical, electro-mechanical, *etc*

COURSE OUTLINE(VISUALIZATION)

- System Analysis:
  - Characterize the "behavior" of the system.

Analysis Tools
- Root locus
- Bode Plot
- Routh Hurwitz
- ...

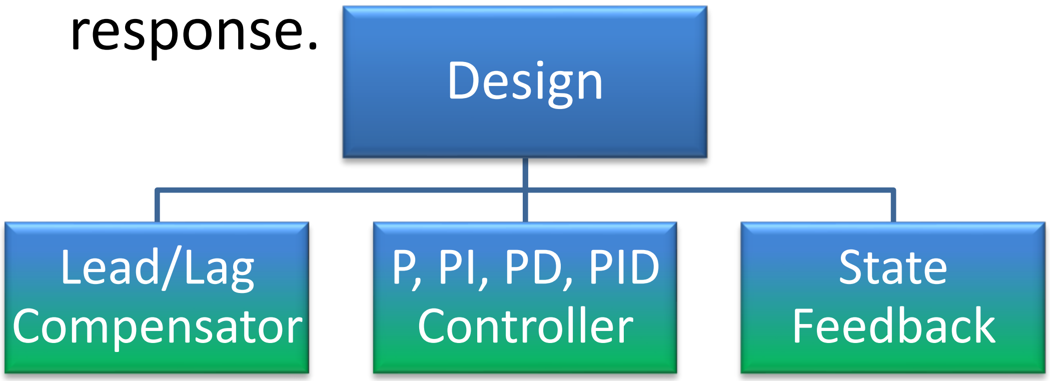


System Stability

System Sensitivity

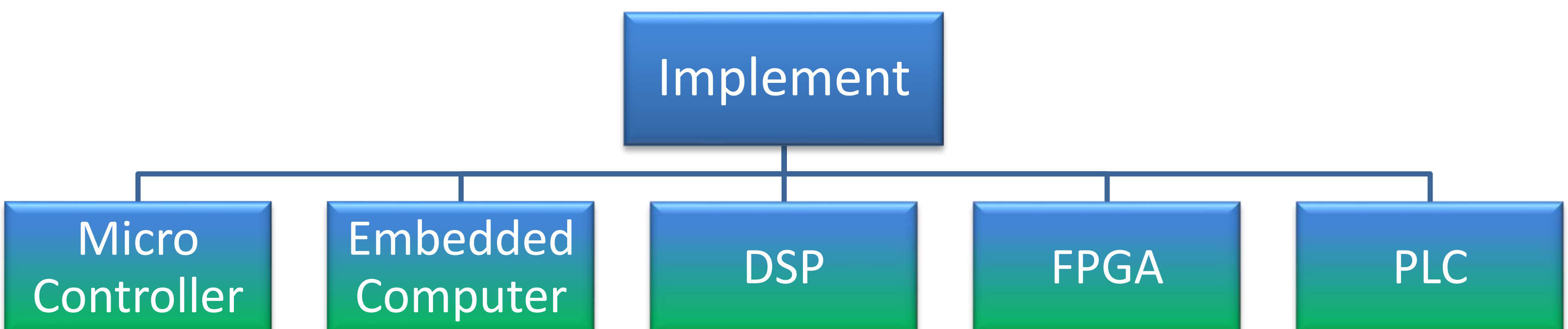
COURSE OUTLINE (VISUALIZATION)

- Controller Design:
  - Add a controller to realize a desired closed-loop system response.



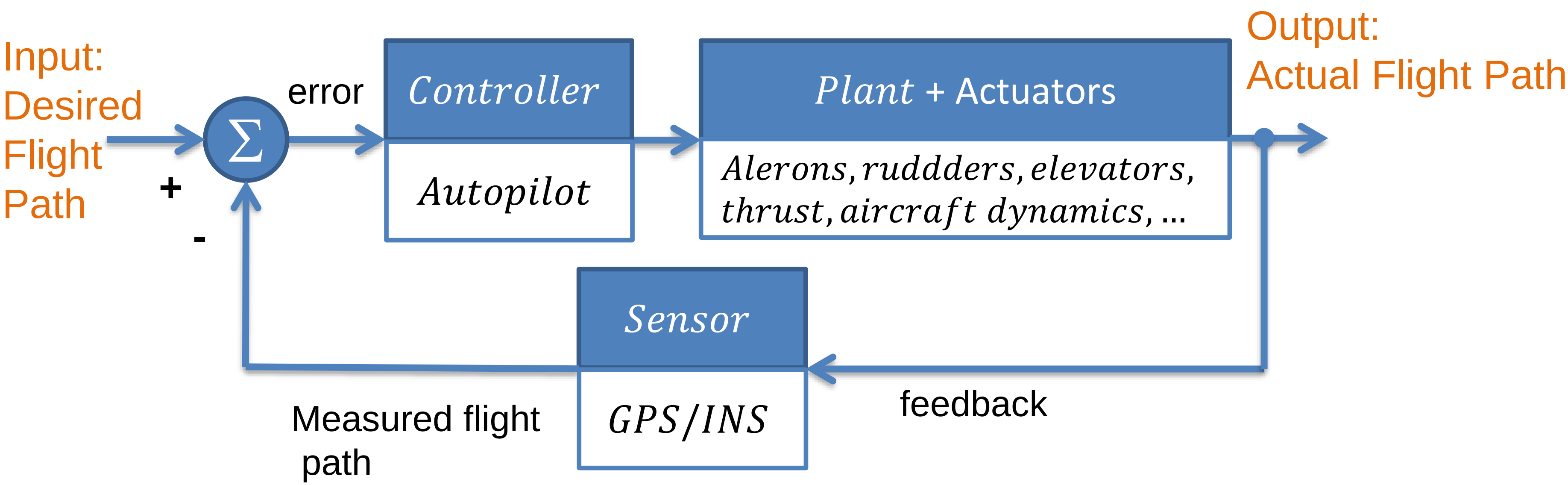
Controller Design Approaches: Root locus, frequency response, Bode Plots, Gain/Phase margins, *etc*…

- Controller Implementation



An Example of a Control System

- Aircraft Flight Path Control System (GNC)
  - Global Position System (GPS) and Inertial Navigation System (INS) - position and attitude sensors



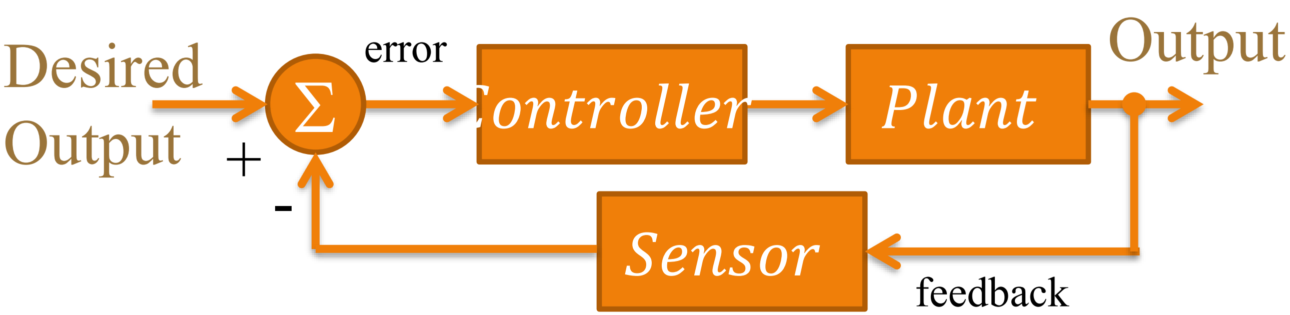
INTRODUCTION TO CONTROL

- A System to be Controlled

Automobile Cruise Control

- Open-Loop Control

- Closed-Loop Control



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ACADEMIC ACCOMMODATIONS

- The University has always strived to meet the needs of individuals with learning disabilities or with other temporary or permanent functional disabilities (hearing/visual impairments, sustained health issues, mental health problems), and the campus community works collaboratively so that you can develop and maintain your autonomy, as well as reach your full potential throughout your studies. You can call on a wide range of services and resources, all provided with expertise, professionalism and confidentiality.
- If barriers are preventing you from integrating into university life and you need adaptive measures to progress (physical setting, arrangements for exams, learning strategies, etc.), contact the Access Service right away:
- in person in our office
- online
- by phone at 613-562-5976

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