Introduction to "Process Dynamics and Control"

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First Year course, MS in Energy Engineering
University of Pisa, Academic Year 2018-2019

Outline

Course teachers

Prof. Gabriele Pannocchia

- Department of Civil and Industrial Engineering (Chemical Engineering)
- Office: @2nd floor (1 floor down main entrance), room 201
- Phone: 050 2217 838
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- Web Site: `https://people.unipi.it/gabriele_pannocchia/`

Objectives of the course

1. Understand the basics of process control system architectures
2. Understand the dynamics of process systems and how to model them
3. Understand the fundamentals of controller design for process systems
4. Understand the basics of advanced process control and optimization

Course syllabus (1/3)

Part I: Introduction and Dynamics

1. Introduction to Process Dynamics and Control (7 hours)
   1. Course presentation
   2. Process control systems: objectives, generalities, examples
   3. Elements of a process control system (measurement devices, standard controllers, actuators)
2. Dynamics of continuous time systems (22 hours)
   1. Physical models described by nonlinear differential equations
   2. Linear differential equations (n-th order and 1-st order)
   3. Example of dynamics of process systems
   4. Laplace Transform and Transfer Function (TF)
   5. Block diagrams
   6. State-Space Linear (SS) systems

Course syllabus (2/3)

Part II: Analysis

1. Stability analysis (6 hours)
   1. Stability definitions
   2. Routh criterion
   3. Root Locus
   4. Effects of poles and zeros
   5. Effects of controller elements (proportional, integral, derivative)
   6. Marginal stability
2. Frequency Analysis (7 hours)
   1. System response to a sinusoidal signal
   2. AR and phase of a linear systems
   3. Bode and Nyquist diagrams
   4. Stability criteria
   5. Comparison of Root Locus and Frequency Analysis

Course syllabus (3/3)

Part III: Design

3. Controller design (11 hours)
    1. Sensibility and Complementary Sensibility function
    2. Control performance (time and frequency) specifications
    3. Controller analytical design and Internal Model Control (IMC)
    4. PID tuning
    5. Effect of uncertainties
    6. More complex control systems: cascade, feedforward, split-range, selective, etc
4. Optimization and advanced control systems (7 hours)
    1. An introduction to numerical optimization
    2. Model Predictive Control systems
    3. Applications to energy systems

Course material

Recommended books

- B. A. Ogunnaike, W. H. Ray. Process Dynamics, Modeling, and Control. *Oxford University Press*, 1994.
- G. Stephanopoulos. Chemical Process Control: An Introduction to Theory and Practice. *Prentice Hall International*, 1985.
- J. P. Hespanha. Linear Systems Theory. *Princeton University Press*, 2009.

Specific material - what?

1. Lecture slides
2. Class exercises and Matlab scripts

Specific material - Where? ... available at the Elearning site:

`http://elearn.ing.unipi.it/course/view.php?id=1219`

- Registration to the course at the Elearning site is mandatory!

Student office hours and list

Student office hours

- GP will be available for questions and clarifications on Friday 14:30-16:30
- Presence must be confirmed by email at `gabriele.pannocchia@unipi.it`
- Quick questions can also be asked by email

Student list

- Each student must be enrolled in the course at the E-learning site
- All communications will be sent via email from E-learning (make sure your address at E-learning is up to date)

Examination

Examination scheme

- Step 0 - Home exercises (Matlab) assigned during the course
- Step 1 (80%) - Written exam (Theory and exercises) - Admission to Step 2 with 18/30
- Step 2 (20%) - Quick oral discussion on exercises