

MECH 467

Computer Control of Mechatronics Systems

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Laboratory sessions will be organized group by group in parallel to lectures.

Learning Objectives:

By the end of this course, students will be expected to be able to design a computer controlled mechatronics system comprised of sensors and actuators.

1. Response analysis of dynamic systems modeled in continuous and discrete time domain
2. Frequency domain analysis of dynamic systems
3. Design of digital control laws for mechatronics systems comprised of mechanical systems, actuators, sensors and electronic circuits.
4. Laboratory implementation of basic computer control principles .

Pre-requisites: MECH 326, MECH 366

Course Outline:

1. Review of dynamic modeling of actuators, sensors and mechanical systems in Laplace Domain.
2. Z Transforms, Discrete equivalent of continuous systems
3. Feedback Control System Characteristics
4. Transient Response of Systems in continuous and discrete domain
5. Frequency Response of Continuous and Discrete Systems
6. Discrete Time and Frequency Domain Identification of Dynamic Systems
7. Nyquist criterion
8. Root-Locus diagrams
9. P, PI, PID Design in continuous and discrete domain using transfer function models
10. Pole Placement Control System Design in continuous and discrete domain using state-space and transfer function models
11. Absolute and Relative Stability of Feedback Control Systems in continuous and discrete domain
12. Regulation, target tracking and disturbance rejection
13. Trajectory Generation for motion control systems
14. Multi-axis motion and interpolation
15. Design of a real time computer controller for a Multi-Axis machine.

Laboratories (examples):

- Modeling and identification of a ball screw driven table, electro-hydraulic system
- Digital Control System Design for a ball screw driven (Part I) and Electro-Hydraulic (Part II) Systems
- Real time computer control system design for a two axis, linear motor driven table

Recommended text: Automatic Control Systems, Kuo and Golnaraghy.

TUTORALS AND LABORATORIES

This course uses MATLAB (PC Lab, PACE Lab) as a mathematical tool and SIMULINK as a real time implementation tool with dSpace. Every student has to implement the algorithms for the four lab projects individually by booking the set up and TAs during designated periods. In order to increase the efficiency of TAs, we opened weekly tutorials which will be delivered by the instructor and TAs. The students are expected to attend the tutorials, and practice the control problems ahead of laboratories. Any student who fails to attend the tutorial will not receive special tutorial by TAs anymore due to the limited TA resources.

Tutorials – Every Monday 12:00-13:30 Tutorial (Altintas and TAs) PACE Lab.

Review of Laplace Transforms, Block Diagram Algebra, Transfer Functions
Identification and Modeling Tutorial
Transient Response, Frequency Response Tutorials

Lab I – Identification and modeling laboratory project tutorial

MATLAB Tutorial, SIMULINK Tutorial
Stability analysis tutorials in s and z domains (Root locus, Bode diagrams)
Control system design tutorials in s and z domain (P, PI, PID, Pole Placement)

Lab II – Control system design and implementation in dSpace and SIMULINK

Linear and circular interpolation tutorial
Trajectory generation algorithms
Real time multi-axis control design, error analysis

Lab III- Two axis real time computer control system design with control and trajectory generation modules. Preparation for Project III

Electro-hydraulic system modeling and control tutorial

Lab IV – Pole placement controller design for electro – hydraulic actuator

Laboratory Procedures:

- Lab. handouts can be downloaded from the links on the web
- Study and test your algorithms at home before trying them in the lab.
- Get the approval of TA before booking the experimental set-up and TA for implementation
- Signup on door at Kaiser 1210 to prove your algorithms in the lab. Each student will need to test his/her algorithm on the machines individually under the supervision of TA.

Project I – Identification and modeling of a motion control system

Complete question #1 of part a) before coming to lab

Project II – Computer control of a motion control system

Simulate and tune proportional and PID control using second order model of system, get the approval of TA.

Bring tuning parameters and simulation results to lab.

Project III – Design of a Multi-Axis Computer Control System

- Simulate and tune the SMC controller for each axis at home, followed by testing in the laboratory
- Simulate the trajectory generator, tool path and controllers in an integrated system at home, followed by actual testing on XY table.
- Complete the testing of all modules
- Submit the final report

Project IV- Electro hydraulic control system

- Step I- Identify the discrete transfer function of the system
- Step II – Design a pole placement controller in SIMULINK, get the approval of TA and implement it in the lab.

Each project must be written professionally (Abstract, Introduction of Theory, Simulation and Experimental Results, Discussions) – To be marked by TAs.

Two Midterms (%25) and a final exam (50%), projects (25%). All projects and labs are compulsory. The students need to obtain passing grade from the exams in order to get 25% credit from the projects towards the final grade.