ME 475
Automatic Control Systems

Course Outcomes [Related ME Program Outcomes in brackets]

1. Provide a thorough understanding of characterization of dynamical systems. [1,2,7]
2. Reinforce and expand topics introduced in ME 365 & ME 375.
3. Provide a thorough treatment of the design of both continuous and discrete systems using Root Locus, State – Space and Frequency Domain methods [1,2,7].
4. Provide feedback controller design experiences through laboratory experiments [1,2,5,6,7].
5. Sharpen technical communication skills through laboratory and project reports [1,3,5].

System Characterization (4 wks)

1. Review of Principles of feedback Control
2. Block Diagram Reduction & Mason's Rules
3. Difference Equations and Effects of Sampling, z-Transforms
4. Stability: Routh – Hurwitz, Bilinear Transforms, Jury's Rules (Necessary only)

Root Locus Methods (3 wks)

1. Principle and Sketching review
2. PD Design
3. Lead Design
4. Lag/Lead Design
5. PID

State Space Methods (4 wks)

1. State – Space review
2. State Feedback Control
3. State Feedback with Integral Control
4. Discrete Data Systems
5. Observers Design
6. Controllability & Observability
7. Similarity Transforms
8. Pole Selection with SRL & introduction to LQR

Frequency Domain Methods (4 wks)

1. Nyquist plots
2. Nyquist stability criterion
3. Relationships between open and closed loop response
4. z – w transforms
5. Frequency warping
6. Performance specifications in frequency domain
7. Bandwidth, Gain & Phase Margins
8. Controller Design Methods
9. Time Delay

Laboratory Experiments

1. Effects of resource limitation on system determinacy
2. Difference Equations
3. Servo Table system identification
4. Root Locus Analysis
   • Introduction to semester design project
   • Laboratory practical exam
5. PID Controller Design
   • Design Project (Modeling)
6. Root Locus Compensator Design
   • Design Project
7. State Space controller design
   • Design Project
8. Frequency Domain Compensator Design
   • Design Project Final and optional contest

COURSE NUMBER: ME 475 **COURSE TITLE:** Automatic Control Systems

REQUIRED COURSE OR ELECTIVE COURSE: Restricted Elective

TERMS OFFERED: Fall and Spring

TEXTBOOK/REQUIRED MATERIAL: Course notes and optional reference: G.F. Franklin, J.D. Powell and A. Emani-Naeini, Feedback Control of Dynamic Systems, 8th ed, Pearson, 2019.

PRE-REQUISITIES: ME 375 System Modeling and Analysis

COORDINATING FACULTY: G. B. King

COURSE DESCRIPTION: Materials introduce in earlier Systems Measurement and Control courses including ME 365 and ME 375 are reinforced and expanded. A thorough treatment of the design of both continuous and discrete system implementations using Root Locus, State Space, and Frequency Domain methods are presented. Laboratory experiments utilizing digital controllers verify and expand on lecture material.

COURSE OUTCOMES [Related ME Program Outcomes in brackets]:

1. Provide a thorough understanding of characterization of dynamical systems. [1,2,7]
2. Reinforce and expand topics introduced in ME 365 & ME 375.
3. Provide a thorough treatment of the design of both continuous and discrete systems using Root Locus, State – Space and Frequency Domain methods [1,2,7].
4. Provide feedback controller design experiences through laboratory experiments [1,2,5,6,7].
5. Sharpen technical communication skills through laboratory and project reports [1,3,5].

ASSESSMENTS TOOLS:

1. Weekly homework.
2. Lab reports.
3. Mid-term exam.
4. Final exam.
5. Special project with report and presentation.

NATURE OF DESIGN CONTENT: The course lectures are oriented toward the design of control systems using various techniques. Each new technique discussed is applied to simple design situations. The laboratory assignments require experimental identification of the dynamical systems as well as design of feedback control systems to meet given performance specifications. The open-endedness and non-uniqueness of acceptable design is emphasized. A final laboratory project with an open-end design challenge and competition ends the semester. A final presentation follows completion of the project.

RELATED ME PROGRAM OUTCOMES:

1. Engineering fundamentals
2. Engineering design
3. Communication skills
4. Ethical/Prof. responsibilities
5. Teamwork skills
6. Experimental skills
7. Knowledge acquisition

PROFESSIONAL COMPONENT:

1. Engineering Topics: Engineering Science – 1.5 credits (50%)
   Engineering Design – 1.5 credits (50%)

COMPUTER USAGE: Students use portable microcontroller devices (NI myRIO) for some homework and projects and in the laboratory. LabVIEW and MATLAB programing is required for analysis, simulation, and system control.

COURSE STRUCTURE/SCHEDULE:
Lecture - 2 days per week at 50 minutes.
Laboratory - 1 day per week at 110 minutes

PREPARED BY: G. B. King **REVISION DATE:** February 06, 2019