

Department of Electrical Engineering

EE 250 CONTROL SYSTEM ANALYSIS

IIT Kanpur

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January 06 20, 2025

Course Objectives

The student shall become comfortable with analyzing and designing *feedback control systems* using the *frequency-domain* tools of *Nyquist stability theory* and *Bode plots-based loopshaping*, which are the core tools that are widely used in, among others, motion-control industry and aerospace industry. Comfort with *PID controllers* shall be a by-product. The student shall also develop comfort with additional practically-useful tools: *block diagrams* and *signal flow graphs*.

The course shall devote some time to understanding the advantages and disadvantages of *root locus approach*, which is an insightful tool.

The course shall present *state-space equations* as tools for the digital implementation of controllers designed using frequency-domain methods.

Course Content

The content of this course, as described in IITK's records is as follows:

Linear feedback control systems, frequency and time domain analysis, I/O relationships, transfer function, performance analysis, Routh-Hurwitz and Nyquist stability criteria, Bode diagrams, Nichols chart, Root locus method, Feedback system design, Non-linear systems, phase-plane analysis, limit cycles, describing functions.

In all, we have 39 50-minute lectures. Here is a tentative list of topics and number of lectures per topic:

1. Preliminaries: Feedback, dynamic systems, transfer functions, block diagrams, signal flow graphs, virtues of control systems (~ 7 lectures)
2. Frequency response and Bode plots (~ 7 lectures)
3. Stability theory, including Nyquist plots (~ 7 lectures)
4. Bode-plot-based loopshaping (~ 8 lectures)
5. Digital implementation of controllers (1 lecture)
6. Pole-placement design using root locus (7 lectures)
7. PID control (2 lectures)

Special Emphasis

All the italicized terms listed under *Course Objectives* shall be emphasized.

Instructor

Instructor Dr. Potluri Ramprasad

E-mail potluri@iitk.ac.in

Lecture Venue & Time L16. T-Th-F 1100 – 1200

Tutorial Venue & Time TB 101 – 105, **TB 203**, Wed 1100 – 1200.

Office hours WL217A/**WL217B**, Th 1700 – 1800

Tutors

Dr. Abhilash Patel	(apatel@...)
Dr. Soumya Ranjan Sahoo	(srsahoo@...)
Dr. Twinkle Tripathy	(ttripathy@...)
Mr. Pradeep M	(pradeepm22@...)
Mr. Mohit Sehrawat	(sehrawat@...)
Mr. Kushal Pratap Singh	(kushalp20@...)

Teaching Assistants

Amit Chaneja	(amitc23@...)
Richik Majumder	(richik24@...)
Harshvardhan Singh	(hsingh24@...)
Shailendra Pratap Singh	(shailendra23@...)
Lisa Naik	(lisanaik24@...)
Neelam Verma	(neelamv24@...)
Insha Rahman	(inshar24@...)
Sura Sivareddy	(ssura23@...)
Shashwat Amit Parikh	(shashwatap24@...)

Aniket Sen	(anikets21@...)
Aravind Seshadri	(aravinds21@...)
Sumay Avi	(sumay21@...)

References

As the subject of this course matured by the 1950's, many books are available in the Indian market. Here are the some (editions are as of 2013):

- Madan Gopal, *Control Systems — Principles and Design*, 3rd ed., Tata McGraw-Hill, 2008.
Gene Franklin, J. David Powell, Abbas Emami-Naeini, *Feedback Control of Dynamic Systems*, 5th ed., Pearson Education, 2006.
K. Ogata, *Modern Control Engineering*, 4th ed., Prentice Hall, 2002.
B.C. Kuo & F. Golnaraghi, *Automatic Control Systems*, 8th ed., John Wiley & Sons (Asia), 2003.
R.C. Dorf & R.H. Bishop, *Modern Control Systems*, 8th ed., Addison Wesley Longman Inc., USA, 1998.

I shall share with the class my lecture notes that I am writing as a book. These lecture notes teach the minimum needed material from the above books and my experience the topics that I have found essential

in practice to analyze, design and build control systems using classical control theory, in the sequence and depth that I have found appropriate.

Plan of Release of Online Lectures

I shall place my lecture notes on MooKIT (HelloIITK).

Assessment Policy

Practice components

Tutorials Each tutorial assignment with 5 – 10 problems is posted 2 – 3 days before the respective tutorial.

M-Tutorials Three tutorials to help you quickly learn the basics of Matlab. These tutorials aim to help you learn Matlab up to a level from where you can further explore it on your own. These tutorials are conducted by the TAs. **Dates TBD later.**

M-quiz A quiz of about 120 minutes involving the design of a control system using loopshaping, assisted by Matlab. This quiz helps round off your practice of this software. **After mid-semester recess.**

In-tutorial quizzes In each tutorial, there is one quiz of 10 – 20 minutes duration **towards the end of the tutorial, and related to that tutorial. Students may use the tutorial to clear doubts and become prepared for the quiz.**

Mid-semester exam and End-semester exam one exam of 2 hours, and one exam of 3 hours.

If you find any topic in the course hard to understand, feel free to discuss with your course-mates, or drop us an e-mail, or visit us in our offices.

Grading system

Your letter grade is based on:

10	10–20 -minute in-tutorial minor quizzes	20%
1	50-minute in-tutorial major quizzes	10%
1	120-minute mid-semester exam	20%
1	120-minute M-quiz	20%
1	180-minute end-semester exam	30%

Policy on make-up quiz/exam

Failure to take a test results in a zero on that test. Due to the large number of students in the class and the large volume of grading, there are no make-up tests.

Attendance Policy

I like it when students attend my classes. Historically, in my courses, a student's attendance and participation have made a difference of up to one letter grade in terms of the old grades (A, B, C, D, E, F).

This course uses biometric attendance. Attendance below 40% results in a fail grade on this course.

Your effort

If you do not understand a concept even after discussing with course-mates, you are welcome to discuss it with me in person. If you e-mail me your questions, I will send an answer to the entire class. We can meet **online** too at a mutually agreed time to discuss your question.

Academic honesty

Throughout the course, you are welcome to discuss all assignments (project and solutions to tests) with your classmates, friends, me, etc. However, you may not copy or help in copying on the tests and the project.

Copying or helping in copying of the tests and exams will result in a fail grade on this course.

Tutors – TAs – Sections – Rooms

Tutor	Teaching Assistants	Section #	Roll #	Room #
Dr. Abhilash Patel	Harshvardhan Singh ¹ , Lisa Naik	1	180488 – 230010	TB101
Dr. Soumya Ranjan Sahoo	Neelam Verma, Insha Rahman	2	230025 – 230249	TB102
Dr. Twinkle Tripathy	Shashwat Amit Parikh, Sumay Avi ¹	3	230255 – 230510	TB103
Mr. Pradeep M	Amit Chaneja, Richik Majumder	4	230513 – 230730	TB104
Mr. Mohit Sehrawat	Aniket Sen, Sura Sivareddy	5	230731 – 230973	TB105
Mr. Kushal Pratap Singh	Aravind Seshadri, Shailendra Pratap Singh	6	230979 – 231199	TB203

¹This TA has given advance notice that he has another course at the same time as this tutorial.