BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
HYDERABAD CAMPUS
SECOND SEMESTER 2023-2024
COURSE HANDOUT (PART II)

Date: 09/01/2024

In addition to part-I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

Course No. **: ECE F242, EEE F242, INSTR F242**
Course Title **: Control Systems**
Instructor-in-charge **: Harish.V. Dixit, Dr. Ankur Bhattacharjee**
Tutorial Instructor-in-charge: Harish.V. Dixit, Dr. Ankur Bhattacharjee, Shaik Sultan, Annaram Sowjanya

1. Scope & Objective of the Course:
Feedback automatic control systems are an essential feature of numerous industrial processes, scientific instruments and even commercial, social and management situations. A thorough understanding of the elementary principles of this all embracing technology is of great relevance for all engineers and scientists. This course tries to bring out the basic principles of Feedback Control Systems.

2. **Learning outcomes:**
By the end of the semester, the students should be able to:

- Develop mathematical models of linear time invariant (LTI) control systems for electrical, mechanical and electromechanical systems.
- Analyze the transient response, steady-state response and system stability of LTI control system.
- Analyze and design control system compensators to achieve specified control system performances in time domain utilizing root-locus techniques.
- Analyze and design control system compensators to achieve specified control system performances utilizing frequency-response techniques.

3. Text Book:
(TB1) Nagrath I. J. and M. Gopal, Control Systems Engineering, New Age International (P) Limited, **5thed**, 2007.

4. Reference Books:
(**R1)** Kuo, B. C., and Golnaraghi, F., Automatic Control Systems, John Wiley & Sons, 8thed, 2003.
(**R2)** Dorf, R. C., and Bishop, R. H., Modern Control Systems, Addison Wesley, 7thed, 1995.
(**R3)** Norman S. Nise, Control System Engineering, John Wiley & Sons, 4th ed, 2009.

5. Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Text Book

1	Introduction Control system terminology-system, control, feedback, transfer function. Linear Time invariant system	General understanding of the concept of control system. Identification of various examples encountered in life from engineering and non-engineering fields as well.	1.1-1.4 and Class notes
2	Introduction to Laplace transform and its application to control systems	Basics of Laplace transform to derive the transfer function, convert differential equation into transfer function and vice versa.	Class Notes and appendix- I
3	Mathematical Modelling. Integro-differential equations for electrical, mechanical systems and Transfer functions, , Gear reduction, disturbance input	Understanding examples from various systems and making block diagram model of the same. Working out transfer function by various methods and gears	Class Notes and 2.1, 2.2
4-5	Block diagram development, closed loop transfer function	Developing a block diagram of applications	Class Notes and 2.5
6-7	Signal flow graph Mason's gain formula, Various Examples	Developing the signal flow graph of a system	Class Notes and 2.6
8	Open loop and closed loop example. Effect on gain, dynamic response disturbance input	Learning about more examples of open loop and closed loop control systems and their comparison	Class Notes and 3.1
9	Sensitivity to parameter variation. Concept of frequency content in signals, regenerative feedback, further examples	To learn the control of system sensitive to parameter variations	Class Notes and 3.2, 3.6, 3.7
10-11	Various Test signals in time domain, Response of zeroth and first order systems Second order systems	Transient and natural response analysis of dynamic first order systems to different excitations	Class Notes and 5.1, 5.2, 5.3 5.4
12-13	Time response specifications of second order systems, error constants, effect of adding pole(s)/zero(s)	Transient and natural response analysis of dynamic second order systems to different excitations	Class Notes and 5.4, 5,5, 5.6
14-15	Compensation Techniques Higher order systems.	To design control system for given time domain specifications.	Class Notes and 5.7, 5.8, 5.10
16-17	Stability; Routh criterion	To apply Routh Test to closed loop system stability study.	Class Notes and 6.1, 6.2, 6.4, 6.5, 6.6
18	Root Locus. Introduction, Magnitude and Angle criterion	To draw root locus for various systems and there from infer information on time response and stability	Class Notes and 7.1, 7.2
19-20	Root Locus for second order systems without zero and with zeros	- do -	Class Notes and 7.2
21	Other rules of root locus. Higher order examples.	- do -	Class Notes and 7.3 7.5
22	Higher order examples (contd.) Root contours	- do -	Class Notes and 7.4
23-24	Frequency Response; Introduction, Polar plot	To plot frequency response of systems and use for analysis by frequency domain approach.	Class Notes and 8.1, 8.2, 8.3
25-26	Nyquist criterion; Introduction. Nyquist contour	Investigation of the stability of closed loop system using their open loop transfer function frequency plot.	Class Notes and 9.1, 9.2, 9.3
27-28	Nyquist stability criterion. Various	- do -	Class Notes

	Examples		and 9.3
29-30	Bode plot	- do -	Class Notes and 8.4
31-33	Identification of Transfer function from Bode plot, Gain margin and phase margin	- do -	Class Notes and 8.5 & 8.6,9.4
34-35	Introduction to Design	To design lag, lead compensators, Tuning of PID controllers	Class Notes and 10.1-10.7
36-42	State variable analysis and design	Analysis and design of a system using state variable approach	Class Notes and 12.1 to 12..9

***The primary reference for the coverage (breadth and depth)/nomenclature/notations for a particular topic would be as per the lectures/tutorials. Students are advised to take class notes during the lectures.**

**** Class notes must be taken in only notebooks, usage of Tabs / any electronic gadgets for taking class notes is strictly prohibited****

6. Evaluation Scheme:

Component	Duration	Weightage	Marks	Date	Remarks
Mid-sem Test	90 min	35 %	105	14/03 - 4.00 - 5.30PM	Closed Book
Comprehensive Exam.	180 minutes	45 %	135	14/05 AN	Closed Book
Continuous evaluation (Quizzes)	--	10%	30	To be announced	Open Book
Continuous evaluation (Tutorial)	--	10%	30	To be announced	Open Book

Note: i. Open book signifies use of hand written class notes, textbook (TB1) will only be permitted.

ii. Solution Manuals/ reference books/ photocopy of books/ printout of notes written on Tabs or any other electronic devices are not permitted.

7. Chamber Consultation Hours: to be announced in the class.

8. Notices: Notices concerning the course will be put up on the CMS/equivalent and/or would be announced in the class.

9. Make-up Policy: No make-up will be given for Assignments and Quizzes in any case. Makeup for mid-sem and Comprehensive Examination will be as per AUGSD rules only in **extremely genuine cases (as per the view of the IC)** for which **prior** permission of the instructor-in-charge is required

10. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Harish V. Dixit
Instructor-In-Charge
ECE F242, EEE F242, INSTR F242