BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER 2019-2020
COURSE HANDOUT (PART II)

Date: 06-01-2020

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**
Instructors **: Dr. Ankur Bhattacharjee**

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:
(T1) 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	Chapter in the 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	2.1, 2.2
4	Mathematical modelling of electromechanical system – example of control of armature and field controlled DC motor as a drive, hydraulic and thermal system examples	Understanding the electromechanical system with DC motor as an example and developing the block diagram	2.4
5-6	Block diagram development, closed loop transfer function	Developing a block diagram of applications	2.5
7-8	Signal flow graph Mason's gain formula, Various Examples	Developing the signal flow graph of a system	2.6,
9	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	3.1
10	Sensitivity to parameter variation. Concept of frequency content in signals, regenerative feedback, further examples	To learn the control of system sensitive to parameter variations	3.2, 3.6, 3.7
11	Examples of servomotor, stepper motor	linearization concept, block diagram and transfer function of real life examples.	4.1, 4,2, 4.3,4.4
12	Hydraulic control system Pneumatic control components	Block diagram and transfer function development	4.5, 4.6
13-14	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	5.1, 5.2, 5.3 5.4
15-16	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	5.4, 5,5, 5.6
17-18	Compensation Techniques Higher order systems.	To design control system for given time domain specifications.	5.7, 5.8, 5.10
19-20	Stability; Routh criterion	To apply Routh Test to closed loop system stability study.	6.1, 6.2, 6.4, 6.5, 6.6
21	Root Locus. Introduction, Magnitude and Angle criterion	To draw root locus for various systems and there from infer information on time response and stability	7.1, 7.2
22-23	Root Locus for second order systems without zero and with zeros	- do -	7.2
24	Other rules of root locus. Higher order examples.	- do -	7.3 7.5
25	Higher order examples (contd.) Root contours	- do -	7.4
25-26	Frequency Response; Introduction,	To plot frequency response of systems and use	8.1, 8.2, 8.3

	Polar plot	for analysis by frequency domain approach.	
27-28	Bode plot	- do -	8.4
29	Identification of Transfer function from Bode plot, Gain margin and phase margin	- do -	8.5 & 8.6,9.4
30	Nyquist criterion; Introduction. Nyquist contour	Investigation of the stability of closed loop system using their open loop transfer function frequency plot.	9.1, 9.2, 9.3
31-32	Nyquist stability criterion. Various Examples	- do -	9.3
33-35	Introduction to Design	To design lag, lead compensators, Tuning of PID controllers	10.1-10.7
36-40	State variable analysis and design	Analysis and design of a system using state variable approach	12.1 to 12..9

6. Evaluation Scheme:

Component	Duration	Weightage	Marks	Date	Nature of Component
Midterm	90 min	30%	90	4/3 1.30 -3.00 PM	CB
Quiz	--	30%	90	To be announced by IC	CB
Comprehensive Exam.	3 hours	20% +20%	60 +60	08/05 FN	CB + OB

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

8. Notices: Notices concerning the course will be put up on the CMS website.

9. Make-up Policy: No make up for quizzes. Make-up for the tests will be granted only on extremely genuine grounds.

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.

Instructor-In-Charge
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