Techno India NJR Institute of Technology

Course File

Control System (5EC4-03)

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For Techno India NJR Institute of Technology

पंकज पोरवाल

Dr. Pankaj Kumar Porwal

(Principal)

Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

III Year - V Semester: B.Tech. (Electronics & Communication Engineering)

5EC4-03: Control system

Credit: 3 | **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P | **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	1
2	Introduction to control problem- Industrial Control examples. Transfer function. System with dead-time. System response. Control hardware and their models: potentiometers, synchros, LVDT, dc and ac servomotors, tacho-generators, electro hydraulic valves, hydraulicservomotors, electro pneumatic valves, pneumatic actuators. Closed-loop systems. Block diagram and signal flow graph analysis.	8
3	Feedback control systems- Stability, steady-state accuracy,transient accuracy, disturbance rejection, insensitivity and robustness. proportional, integral and derivative systems. Feedforward and multi-loop control configurations, stability concept, relative stability, Routhstability criterion.	7
4	Time response of second-order systems- steady-state errors and error constants. Performance specifications in time-domain. Root locus method of design. Lead and lag compensation.	6
5	Frequency-response analysis- Polar plots, Bode plot, stability in frequency domain, Nyquistplots. Nyquist stability criterion. Performance specifications in frequency-domain. Frequency domain methods of design, Compensation & their realization in time & frequency domain. Lead and Lag compensation. Op-amp based and digital implementation of compensators. Tuning of process controllers. State variable formulation and solution.	8
6	State variable Analysis- Concepts of state, state variable, state model, state modelsfor linearcontinuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability &observability.	6
7	Introduction to Optimal control & Nonlinear control, Optimal Control problem, Regulator problem, Output regulator, treking problem. Nonlinear system – Basic concept & analysis.	6
	Total	**42**

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Course Overview:

This course provides an introduction to linear systems, transfer functions, and Laplace transforms. It covers stability and feedback and provides basic design tools for specifications of transient response. It also briefly covers frequency-domain techniques. It provides students with a basic understanding of the concepts and techniques involved in designing control schemes for dynamic systems.

After completing the course students in-depth knowledge of concepts from classical control theory, understand the concept of the transfer function and use it for obtaining system response, analyze dynamic systems for their stability and performance, and design controllers (such as Proportional-Integral-Derivative) based on stability and performance requirements will increase.

It is a very important course from an industrial application point of view because todays each system is a feedback control system and knowledge of designing the feedback control is very important. This eventually helps students to get a recruit.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	To identify the various machines, working Principle, Characteristics and their applications.
2	Synthesis	To analyze the principles of system modelling, feedback control and evaluate feedback control systems with desired performance.
3	Analysis	To understand system stability, sensitivity, transient and tracking performance.
4	Application	To control system design such as the design of feedback controllers, such as PID, lead and lag compensators, pole placement designs, to meet desired system performance specifications.

Prerequisites:

1. System Modelling, Ordinary Differential Equations
2. A good grasp of Linear Algebra and Complex Analysis.

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3. Prefer that they have completed a course on engineering mathematics that teaches complex variables and Laplace transform.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	**Domain Specific (PSO)**					**Domain Independent (PO)**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	-	1	-	-	-	1	-	-	-
CO2	2	2	2	-	1	-	-	-	1	-	-	-
CO3	2	1	2	-	1	-	-	-	-	-	-	-
CO4	2	2	1	3	2	-	-	-	2	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**INTRODUCTION:** objective, scope and outcome of the course.
2	**2**	**INTRODUCTION TO CONTROL PROBLEM**- Industrial Control examples
3	2	Transfer function. System with dead-time.
4	2	System response. Control hardware and their models:
5	2	Potentiometers, synchros, LVDT, dc and ac servomotors
6	2	Tacho-generators, electro hydraulic valves
7	2	Hydraulicservomotors, electro pneumatic valves, pneumatic actuators.
8	2	Closed-loop systems. Block diagram and signal flow graph analysis.
9	**3**	**CLOSED-LOOP SYSTEMS** Block diagram and signal flow graph analysis.
10	3	Feedback control systems- Stability, steady-state accuracy, transient accuracy
11	3	Disturbance rejection, insensitivity and robustness.
12	3	Proportional, integral and derivative systems.
13	3	Feedforward and multi-loop control configurations,
14	3	Stability concept, relative stability
15	3	Routhstability criterion.
16	**4**	**TIME RESPONSE OF SECOND-ORDER SYSTEMS**
17	4	Steady-state errors and
18	4	Error constants.
19	4	Performance specifications in time-domain.
20	4	Root locus method of design.
21	4	Lead and lag compensation
22	4	Lead and lag compensation

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23	**5**	**FREQUENCY-RESPONSE ANALYSIS**- Polar plots, Bode plot
24	5	Stability in frequency domain, Nyquistplots. Nyquist stability criterion
25	5	Performance specifications in frequency-domain. Frequency domain methods of design
26	5	Compensation & their realization in time & frequency domain.
27	5	Op-amp based and digital implementation of compensators.
28	5	Tuning of process controllers.
29	5	State variable formulation and solution.
30	**6**	**STATE VARIABLE ANALYSIS- Concepts of state**
31	6	State variable, state model,
32	6	State models for linear continuous time functions,
33	6	State models for linear continuous time functions,
34	6	Diagonalization of transfer function,
35	6	Solution of state equations
36	6	Concept of controllability & observability.
37	**7**	**INTRODUCTION TO OPTIMAL CONTROL & NONLINEAR CONTROL**
38	7	Optimal control
39	7	Problem, Regulator problem,
40	7	Output regulator,
41	7	Treking problem.
42	7	Nonlinear system – Basic concept & analysis

Text/Reference Books:

1. Smarjit Ghosh, Control Systems: Theory and Applications, 2/e, Pearson Publisher. 2004
2. Dhannesh N. Manik: Control System, Cengage Learning. 2012
3. I. J. Nagrath and M. Gopal: Control Systems Engineering, 3rd Ed, New Age Publication.
4. K. R. Varmah: Control Systems, MGH 2010
5. Anandnatrajan et. al.: Control Systems Engineering, 4th ed., Scitech Pub.

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/107/106/107106081/ https://nptel.ac.in/courses/108/106/108106098/
Quiz	https://quizizz.com/admin/quiz/5f31cc43d8a6f3001b6f2f9e/control-system
Notes	https://sites.google.com/site/eeenotes2u/courses/control-systems

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Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous Year Question Paper:

5E1393

5E1393

B. Tech. V - Sem. (Main / Back) Exam., Feb.-March - 2021

PCC/PEC Electronics & Communication Engineering

5EC 4–03 Control System

Time: 2 Hours **[To be converted as per scheme]**

Max. Marks: 82

Min. Marks: 29

Instructions to Candidates:

Attempt all ten questions from Part A, four questions out of seven questions from Part B and two questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 Explain Digital control system. [2]

Q.2 Write difference between transient and steady state response. [2]

Q.3 What is Tachogenerator? [2]

Q.4 Define Insensitivity and Robustness. [2]

Q.5 Define lead compensation. [2]

Q.6 Define state, state variable. [2]

Q.7 Define Phase margin and Gain margin. [2]

Q.8 Explain the multivariable control system. [2]

Q.9 Define relative stability. [2]

Q.10 Explain PID controller. [2]

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PART – B

(Analytical/Problem solving questions) [4×8=32]

Attempt any four questions

Q.1 Define the open loop and closed loop systems. Draw the block diagram representation of open loop & closed loop system by assuming suitable example. Compare the advantages & disadvantages. [8]

Q.2 How an armature controlled DC motor is used in control system applications? Give a schematic diagram, derive the transfer function and draw a block for the system. [8]

Q.3 The block diagram of a simple servo system shown in given fig 1. Find - [1×8=8]

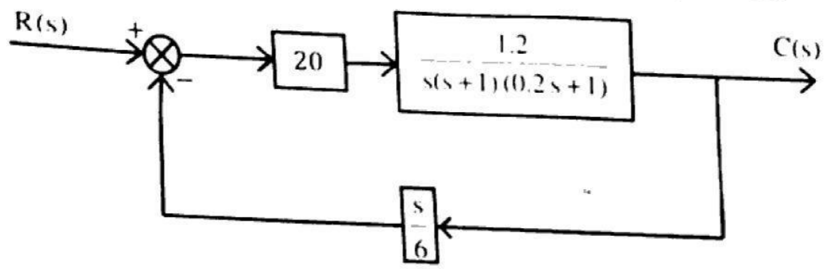

Fig.1

(a) The characteristics equation of the system

(b) Undamped frequency of oscillations

(c) Damped frequency of oscillations

(d) Damping Ratio

(e) Damping factor

(f) Maximum overshoot

(g) First undershoot

(h) Settling time

Q.4 With the help of Routh – Hurwitz criterion, comment upon the stability of the system having the following characteristic equation - [8]

$$s^6 + s^5 + 8s^4 + 6s^3 + 20s^2 + 8s + 10 = 0$$

Q.5 Using Nyquist criterion find out whether the system given below is stable –

$$G(s)\,H(s) = \frac{1}{(1+s)^2}$$

Q.6 Write short notes on –

(a) Optimal control system

(b) Nonlinear control system [4]

Q.7 Diagonalize the system whose state model is given below. [4]

[8]

$$\dot{x} = \begin{bmatrix} 3 & 4 \\ 2 & 1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

and $y = [8 \quad 1]x$

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) [2×15=30]

Attempt any two questions

Q.1 For the feedback control system shown in the fig.2 – [3×5=15]

(a) Find $\frac{C}{R}$ using block diagram reduction method

(b) Find $\frac{C}{R}$ using Mason's gain formula

(c) If $G_1 = 10$, $G_2 = 5$, $G_3 = 8$, $H_1 = 1$, $H_2 = 0.25$, $H_3 = 0.2$ and $R = 10.1$, find the input to block G_2.

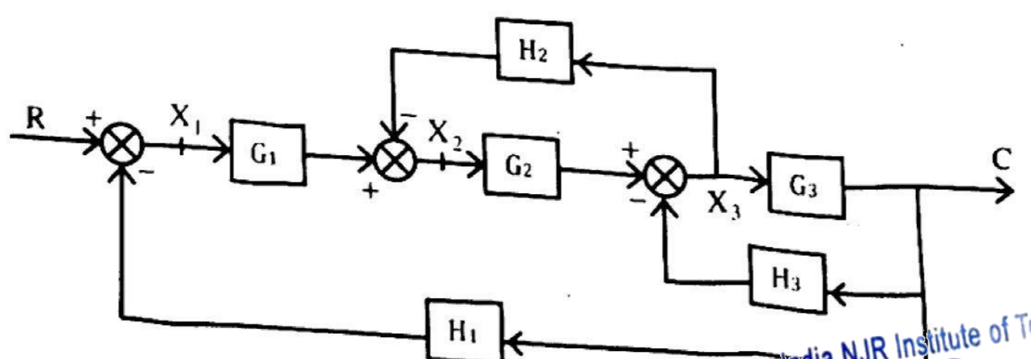

Fig.2