

LINEAR CONTROL SYSTEMS

Subject Code : 23ES2201E

Regulations : IS - 23

Class : B.Tech II Year ECE II Semester

Course Coordinator : Dr Y.RAJASREE RAO, Principal



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COURSE PLANNER

I. COURSE OVERVIEW:

In this course it is aimed to introduce to the students the principles and applications of control systems in everyday life. The basic concept of block diagram reduction, time domain analysis solutions to time invariant systems and also deals with the different aspects of stability analysis of systems in time domain and frequency domain.

II. PREREQUISITES:

Linear Algebra and Calculus, Ordinary Differential Equations and Multivariable Calculus Laplace Transforms, Numerical Methods and Complex variables.

III. COURSE OBJECTIVES:

At the end of the course, the students will be able to:

S.No	Description
1	To understand the different ways of system representations such as Transfer function representation and state space representations and to assess the system dynamic response.
2	To assess the system performance using time domain analysis and methods for improving it.
3	To assess the system performance using frequency domain analysis and techniques for improving the performance.
4	To design various controllers and compensators to improve system performance.

IV .COURSE OUTCOMES:

S.No	Description	Bloom's Taxonomy Level
CO1	Understand the modeling of linear-time-invariant systems using transfer function and state space forms.	Knowledge, Understand (Level 1, Level 2)
CO2	Understand various feedback control strategies.	Knowledge, Understand (Level 1, Level 2)
CO3	Analyze the system response and stability in both time-domain and frequency domain.	Knowledge, Analyze (Level 1, Level 4)
CO4	Apply and Design different types of compensators using in time-domain and frequency domain specifications.	Apply, Evaluate (Level 3, Level 5)

CO5	Analyze the system response and stability of systems represented in state space form	Analyze (Level 4)
CO6	Model and Analyze the linear discretized time systems.	Create, Analyze (Level 5, Level 4)

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems related to Computer Science and Engineering.	2	Lectures, Assignments university exams.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems related to Computer Science and Engineering and reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Slip tests, Surprise tests and Mock tests
PO3	Design/development of solutions: Design solutions for complex engineering problems related to Computer Science and Engineering and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Hands on Practice sessions
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Sessions and model developments
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Practices new methods
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Computer Science and Engineering professional engineering practice.	-	-

PO7	Environment and sustainability: Understand the impact of the Computer Science and Engineering professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	-
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	-	-
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	-	-
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	-	-
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	Workshops /Develop new projects
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Projects and seminars

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSO)		Level	Proficiency assessed by
PSO1	Talented to analyze, design, and implement electrical & electronics systems and deal with the rapid pace of industrial innovations and developments	2	Participate events, seminars and symposiums Experiments / Tools /Projects
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical & Electronics Engineering domain.	2	Participate events, seminars and symposiums Experiments / Tools /Projects

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

VII. COURSE CONTENT: SYLLABUS

SYLLABUS

UNIT I - INTRODUCTION

Concepts of System, Control Systems: Open Loop and closed loop control systems and their differences. Different examples of control systems, Feed-Back Characteristics, Effects of feedback. Mathematical models, Differential equations, Impulse Response and transfer functions. Translational and Rotational mechanical systems .

UNIT II – TRANSFER FUNCTION REPRESENTATION

Transfer Function of DC Servo motor - AC Servo motor- Synchro-transmitter and Receiver, Block diagram representation of systems considering electrical systems as examples –Block diagram algebra–Representation by Signal flow graph-Reduction using mason's gain formula.

Time Response Analysis

Standard test signals – Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems – Time domain specifications – Steady state response - Steady state errors and error constants.

UNIT III – STABILITY ANALYSIS IN S-DOMAIN

The concept of stability – Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability.

Root Locus Technique:

The root locus concept - construction of root loci-effects of adding poles and zeros to $G(s)H(s)$ on the root loci .

UNIT IV

Frequency response analysis: Introduction, Correlation between time and frequency response, Polar Plots, Bode Plots, Nyquist Stability Criterion .

UNIT V – CLASSICAL CONTROL DESIGN TECHNIQUES

Compensation techniques – Lag, Lead, Lead-Lag Controllers design in frequency Domain, PID Controllers. State Space Analysis of Continuous Systems Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and its Properties – Concepts of Controllability and Observability.

TEXT BOOKS:

1. Automatic Control Systems 8th edition– by B.C.Kuo – Johnwiley and son's, 2003.
2. Control Systems Engineering –by I. J.Nagrathand M.Gopal, New Age International (P) Limited, Publishers, 2nd edition, 2007
3. Modern Control Engineering–by Katsuhiko Ogata–Pearson Publications, 5th edition, 2015.

REFERENCE BOOKS:

1. Control Systems by A.Nagoorkani, RB Apublications, 3 edition, 2017.
2. Control Systems by A.Anandkumar, PHI, 2 Edition, 2014.

VIII. LESSON PLAN COURSE SCHEDULE:

Ses sion	Topic to be covered	Bloom' s Taxono my	Teaching Methodology	Reference Text Books
1	Introduction to subject Brief description of syllabus Explanation of program outcomes and course outcomes.	L1:Remember	Chalk & Talk	T1-CH1
2	Concepts of Control Systems- Open Loop and closed loop control systems and their differences	L2:understand	Chalk & Talk	T1-CH1
3	Different examples of control systems	L4:Analyze	PPT	T1-CH1
4	Classification of control systems & Transfer function and its properties	L2:understand	Chalk & Talk	T1-CH1
5	Explanation of Feedback systems & Feed-Forward Characteristics	L2:understand	Chalk & Talk	T1-CH3
6	Effects of feedback on control systems & Sensitivity of control systems	L2:understand	Chalk & Talk	T1CH3
7	Introduction Mathematical models of mechanical transitional system with differential equations	L2:understand	Chalk & Talk	T1CH3
8	Problems on mechanical transitional system	L4:analyze	Chalk & Talk	T1-CH2
9	Introduction Mathematical models of mechanical rotational system with differential equations	L2:understand	Chalk & Talk	T1-CH2
		L2:understand	Chalk & Talk	T1-CH2
10	Problems on mechanical rotational system	L4:analyze	Chalk & Talk	T1-CH2
11	Conversion of mechanical system to electrical system-force voltage and force current analogy	L4:analyze	Chalk & Talk	T1-CH2
12	Transfer Function of DC Servo motor - AC Servo motor.	L2:understand	Chalk & Talk and practical experiment	T1-CH4
13	Synchro transmitter and Receiver	L2:understand	Chalk & Talk and practical experiment	T1-CH4

14	Block diagram representation of systems considering electrical systems with examples	L2:understand	Chalk & Talk	T1-CH4
15	Block diagram algebra	L2:understand	Chalk & Talk	T1-CH2
16	Problems on block diagrams	L4:analyze	Chalk & Talk	T1-CH2
17	Representation by Signal flow graph & Reduction using mason's gain formula.	L4:analyze	Chalk & Talk	T1-CH2
18	Problems on signal flow graphs	L4:analyze	Chalk & Talk	T1-CH2
19	# Bridge class-1			
20	# Mock test-1			
21	Introduction to Time Response & Standard test signals	L2:understand	Chalk & Talk	T1-CH5
22	Time domain specifications ,order and type of the system Problems on time domain specifications	L2:understand	Chalk & Talk	T1-CH5
23	Time response of first order & Second order systems – Characteristic Equation of Feedback control systems	L2:understand	Chalk & Talk and practical experiment	T1-CH5
24	Problems on transient response	L4:analyze	Chalk & Talk	T1-CH5
25	Type number of the systems and error constants	L2:understand	Chalk & Talk	T1-CH5
26	Steady state errors & Problems on steady state errors	L2:understand	Chalk & Talk	T1-CH5
27	Effects of proportional derivative, proportional integral systems.	L2:understand	Chalk & Talk and with simulation experiment	T1-CH5
28	The concept of stability & Location of roots in S-plane for stability analysis	L2:understand	Chalk & Talk	T1-CH6
29	Stability analysis with characteristic equation of control systems	L2:understand	Chalk & Talk	T1-CH6
30	Routh stability criterion & Problems on Routh criterion	L4:analyze	Chalk & Talk	T1-CH6
31	qualitative stability and conditional stability & The root locus concept	L2:understand	Chalk & Talk	T1-CH6

32	construction of root loci	L2:understand	Chalk & Talk and with simulation experiment	T1-CH7
33	Problems on root locus	L4:analyze	Chalk & Talk	T1-CH7
34	Problems to find dominant poles & effects of adding poles and zeros to G(s) H(s) on the root loci	L4:analyze	Chalk & Talk	T1-CH7
35	# Bridge Class-2			
36	Introduction Frequency Response Analysis & definitions of Frequency domain specifications	L2:understand	Chalk & Talk	T1-CH8
37	frequency domain specifications for a second order system	L2:understand	Chalk & Talk	T1-CH8
38	Correlation between time domain and frequency domain specifications & Introduction to frequency response plots	L2:understand	Chalk & Talk	T1-CH8
39	Procedure to draw bode plots & determine phase margin and gain margin and stability analysis	L2:understand	PPT	T1-CH8
40	Problems on bode plots	L4:analyze	Chalk & Talk	T1-CH8
41	Determination of Frequency domain specifications and transfer function from the Bode Diagram	L4:analyze	Chalk & Talk and with simulation experiment	T1-CH8
42	Problems to determine transfer function from bode diagram	L4:analyze	Chalk & Talk	T1-CH8
43	Introduction to Polar Plots & Procedural steps to draw polar plots	L2:understand	Chalk & Talk and with simulation experiment	T1-CH8
44	Problems on polar plots	L4:analyze	Chalk & Talk	T1-CH8
45	Introduction to Nyquist plot & Stability analysis using Nyquist criterion	L2:understand	PPT	T1-CH9
46	Procedural steps to draw Nyquist plots	L2:understand	Chalk & Talk	T1-CH9
47	Effects of adding poles and zeros to G(s)H(s) on the shape of the Nyquist diagrams.	L4:analyze	PPT and simulation experiment	T1-CH9
48	Problems on Nyquist plot	L4:analyze	Chalk & Talk	T1-CH9
49	#Bridge Class-4			
50	Introduction to compensation techniques & Lag compensator and procedure to design it	L2:understand	Chalk & Talk	T1-CH10

51	Lead compensator & Lead Lag compensator and procedure to design it	L2:understand	Chalk & Talk	T1-CH10
52	Problems on compensators& PID controllers	L4:analyze	Chalk & Talk	T1-CH10
53	#mock test-2			
54	Introduction to State Space Analysis of Continuous Systems & its advantages and applications	L2:understand	Chalk & Talk	T1-CH12
55	Definitions of state space, state variables ,state model & State diagram representation of a control system	L2:understand	Chalk & Talk	T1- CH12
56	State space representation of an electrical network and problems on it & derivation of state models from block diagrams	L2:understand	Chalk & Talk	T1- CH12
57	derivation of state models from transfer function using signal flow graph method	L2:understand	Chalk & Talk	T1- CH12
58	derivation of state models from transfer function using direct decomposition method	L2:understand	Chalk & Talk	T1- CH12
59	derivation of state models from transfer function using cascade method	L2:understand	Chalk & Talk	T1- CH12
60	derivation of state models from transfer function using canonical method	L2:understand	Chalk & Talk	T1- CH12
61	derivation of transfer function from state models & state diagram	L2:understand	Chalk & Talk	T1- CH12
62	Diagonalization & Introduction To State Equations	L2:understand	Chalk & Talk	T1- CH12
63	State Transition Matrix And Its Properties & Methods To Determine The Matrix & Problems on state transition matrix	L2:understand	Chalk & Talk	T1- CH12
64	Solving the Time invariant state Equations(non homogeneous)	L4:analyze	Chalk & Talk	T1- CH12
65	Solving the Time invariant state Equations(non homogeneous)	L4:analyze	Chalk & Talk	T1- CH12
66	*Controllability & Observability	L2:understand	Chalk & Talk	T1- CH12

* (content beyond syllabus)

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	-	3	2
CO2	2	3	2	2	1	-	-	-	-	-	-	-	3	2
CO3	2	3	3	2	2	-	-	-	-	-	-	-	3	2
CO4	3	3	3	2	2	-	-	-	-	-	-	-	3	2
CO5	2	1	2	2	1	-	-	-	-	-	-	-	2	2
CO6	2	2	2	2	2	-	-	-	-	-	-	-	2	2

1: Slight (Low)

2: Moderate (Medium)

3: Substantial (High)

WEBSITES:

1. <http://nptel.iitm.ac.in>
2. <http://www.ieeecss.org>
3. www.wikipedia.com
4. www.wikibooks.org
5. www.google.com

JOURNALS:

1. IEEE Control Systems Magazine
2. International Journal of Systems, Control and Communications
3. The International Journal of INTELLIGENT CONTROL AND SYSTEMS
4. ICGST International Journal on Automatic Control and System Engineering
5. Journal of Control Engineering and Technology

LIST OF TOPICS FOR STUDENT SEMINARS:

1. Concept of Control Systems
2. Mathematical Modeling of Control Systems
3. Block Diagram reduction Techniques
4. Signal flow Graph.
5. Time Response Analysis
6. Time Domain Specifications
7. Frequency Response Analysis
8. Root Locus Techniques
9. Bode Plots