22EE440 CONTROL SYSTEMS

Category	L	T	P	Credit
PCC	2	1	0	3

Preamble

This course is to impart students the knowledge of fundamental principles in control engineering. The course includes: Mathematical Modeling of Linear Continuous Time Invariant Single Input - Single Output Dynamical Systems, Transfer Functions and State Space Models, Performance Specifications, and Analysis of Closed Loop Control Systems using time domain and frequency domain approaches.

Prerequisite

- 22EE230 : Electric Circuit Analysis
- 22EE340 : Signals and Systems
- 22EE210: Matrices and Transforms

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome 1 (CO1)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment %
CO1	Determine the transfer function and state space model of the given electrical, mechanical and electro-mechanical system	TPS3	70%	70%
CO2	Analyze the time response characteristics of a given transfer function model	TPS4	70%	70%
CO3	Analyze the frequency response characteristics of a given transfer function model	TPS4	70%	70%
CO4	Analyze the closed loop characteristics of a given transfer function model using root locus	TPS4	70%	70%
CO5	Explain the effects of compensators in improving the performance of the system	TPS2	80%	80%
CO6	Determine the stability, controllability and observability of the given dynamical system	TPS3	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1						2					
CO2	3	3	2	2						2		2			
CO3	3	3	2	2						2		2			
CO4	3	3	2	2						2		2			
CO5	2	1								2					
CO6	3	2	1	1						2					

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1				CAT 2				ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	4	1	2	3	4	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10	30						40								2	6	15	
CO2	5	10	10	30					60								2		6	7
CO3					2	10	10	10					50				2		7	6
CO4					2		10	10					50				2		7	7
CO5					4	10												8		
CO6					2	10	20										2	6	15	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Modeling:

Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback, Transfer function models of linear time invariant systems. Concept of state variable, state space model. Mathematical models of electrical, mechanical and electromechanical systems, Block diagram reduction, signal flow graphs and Mason gain formula.

Time domain analysis and stability:

Test Signals, Steady state errors, Time response of First order and second order systems- Dominant pole approximation of higher order systems, Concept of Stability and Characteristic equation, Routh-Hurwitz criteria- Root-locus construction and interpretation, closed loop analysis using root locus, Time domain and root locus analysis using MATLAB.

Frequency-domain analysis:

Frequency responses and Frequency domain specifications, Bode plot, polar plot, construction and interpretation, Nyquist stability criterion- Gain and phase margin, Frequency domain analysis using MATLAB.

Compensation:

Types of compensators, characteristics and effects of lead, lag, lag-lead compensators and P, PI and PID controllers.

State Variable Analysis:

Relation between state space and transfer functions, canonical forms, solution of state equation, Eigen values and stability analysis, Controllability and Observability.

Text Book

1.Norman S. Nise, Control Systems Engineering, 6th edition, John Wiley, 2010. (Indian edition)

Reference Books& web resources

1. I.J. Nagrath and M Gopal, Control Systems engineering, 5th Edition, New Age International, 2007
2. Robert H Bishop and Richard C Dorf, Modern Control Systems, 12th Edition, Pearson Education, 2010
3. John JD Azzo, Constantine H Houpis, and Stuart N Sheldon, Linear Control Systems: Analysis and Design with MATLAB, 5th Edition, Taylor and Francis, 2003
4. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India Pvt limited 2014. (Student edition)
5. Katsuhiko Ogata, Modern Control Engineering, 5th edition, PHI, 2010
6. M Gopal, Control Systems-Principles and Design, 4th Edition, McGraw Hill India, 2012
7. NPTEL Online Course: Control Systems, URL: https://nptel.ac.in/courses/107106081/72

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods

Module No.	Topic	No. of Periods
1	**Modeling**	
1.1	Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback	2
1.2	Transfer function models of linear time invariant systems	1
1.3	Mathematical models of electrical, mechanical and electromechanical systems	3
1.4	Block Diagram reduction	1
1.5	Signal flow graph and mason gain formula	2
1.6	Concept of state variable, state space model	2
2	**Time domain analysis and stability**	
2.1	Test Signals, Time response of First order systems	1
2.2	Time response of second order systems	2
2.3	Dominant pole approximation of higher order systems,	1
2.4	Steady state errors	1
2.5	Concept of Stability and Characteristic equation, Routh-Hurwitz criteria	2
2.6	Root-locus construction and interpretation, closed loop analysis using root locus,	2
2.7	Time domain and root locus analysis using MATLAB	1
3	**Frequency-domain analysis**	
3.1	Frequency responses and Frequency domain specifications,	1
3.2	Bode plot, construction and interpretation,	2
3.3	polar plot ,construction and interpretation	2
3.3	Nyquist stability criterion- Gain and phase margin	2
3.4	Frequency domain analysis using MATLAB.	1
4	**Compensation**	
4.1	Types of compensators, Characteristics and effects of lead, lag, lag-lead compensators	2
4.2	Characteristics of P, PI and PID controllers	1
5	**State Variable Analysis**	

Module No.	Topic	No. of Periods
5.1	Relation between state space and transfer functions, canonical forms	1
5.2	Solution of state equation, Eigen values and stability analysis,	2
5.3	Controllability and Observability	1
	Total	36

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