16EC209 LINEAR CONTROL SYSTEMS

Hours Per Week :

L	T	P	C
3	-	-	3

Course Description and Objectives:

This course enables applications of mathematical modeling of physical systems (electrical, mechanical, chemical, thermal and pneumatic systems) and presents different methods of analysis and design. The aim of this course is to provide the knowledge in various time and frequency domains, tools for analysis and design of linear control systems and compensators.

Course Outcomes:

Upon successful completion of this course, students should be able to:

CO1: Calculate the transfer function of different control systems.

CO2: Apply mathematical modeling to the physical systems/electrical systems.

CO3: Understand and analyze the characteristics of feedback systems.

CO4: Analyze the response of the open and closed loop systems with time domain and state space analysis. CO5: Design lag, lead and lead-lag compensators and PID controllers.

CO6: Investigate the stability of a given control system by using RH, Root locus, Bode plot and Nyquist plot.

SKILLS:

- ✓ *Model any physical system (Electrical, Mechanical, Electro-mechanical).*
- ✓ *Determine overall transfer function of a system using block diagram reduction technique and SFG method.*
- ✓ *Analyze first and second order systems in time domain.*
- ✓ *Determine design specifications like rise time, settling time, steady state error.*
- ✓ *Analysis of stability using R-H Criterion.*
- ✓ *Determine open loop gain variation in a stable system using root locus method.*
- ✓ *Stability analysis of any system in the frequency domain.*
- ✓ *Design of lag, lead compensators using R, L and C for any linear time invariant system.*

ACTIVITIES:

- *Realize the Lag, Lead Compensators using R,L and C for any specifications.*
- *Analyze time response of second order system using MATLAB.*
- *Analyze LTI system for stability using MATLAB.*
- *Design PID controller.*

UNIT - 1 **L-11**

INTRODUCTION TO CONTROL SYSTEMS: Introduction, Concept of control systems, Open loop versus closed loop control systems, Different examples of control systems, Classification of control systems, Mathematical Models of Physical Systems, Differential equations, Transfer function and block diagram representation of systems considering electrical systems as examples, Block diagram algebra, Signal flow graph representation, Reduction using Mason's gain formula, Translational and rotational mechanical systems.

UNIT - 2 **L-6**

FEED-BACK CHARACTERISTICS AND CONTROL COMPONENTS: Feedback, Effects of feedback, Control over system dynamics by the use of feedback, Elements of control systems, Transfer function derivation of DC Servo motor, AC servo motor, Synchro transmitter and receiver.

UNIT - 3 **L-9**

TIME RESPONSE ANALYSIS AND STABILITY: 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, Stability - The concept of stability, Routh stability criterion.

UNIT - 4 **L-10**

RL TECHNIQUE AND FREQUENCY RESPONSE ANALYSIS: Root locus technique - The root locus concept, Construction of root loci; Frequency response analysis - Introduction, Frequency domain specifications, Bode diagrams, Determination of frequency domain specifications from the Bode diagram, Phase margin and gain margin, Stability analysis from Bode plots, Polar plots, Nyquist plots and Nyquist stability criterion.

UNIT - 5 **L-9**

DESIGN AND MODERN CONTROL SYSTEMS: The design problem, Preliminary design considerations, Realization of basic compensators - Lead, Lag and Lead-lag; PID controllers, State space analysis of continuous systems - Concepts of state, State variables and state model, Derivation of state models from block diagrams, Solving the time invariant state equations, State transition matrix, Controllability and observability.

TEXT BOOKS:

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", 2nd edition, New Age International (P) Limited, 2009.
2. Katsuhiko Ogata, "Modern Control Engineering" 5th edition, Prentice Hall of India Private Ltd, New Delhi, 2011.

REFERENCE BOOKS:

1. M. Gopal, "Control Systems: Principles and Design", 3rd edition, McGraw Hill, 2008.
2. Benjamin C Kuo and Farid Golnaraghi, "Automatic Control systems", 9th edition, Prentice Hall of India PrivateLtd, New Delhi, 2009.
3. Richerd C. Dorf and Robert H. Bishop, "Modern Control Systems", 12th edition, Prentice, Hall, 2010.
4. S.Salivahanan, R.Rengaraj and G.R. Venkata Krishnan, "Control Systems Engineering", 1st edition, Pearson, 2015.