

CONTROL SYSTEMS

COURSE OBJECTIVES:

1. Merits and demerits of open loop and closed loop systems; the effect of feedback.
2. The use of block diagram algebra and Mason's gain formula to find the overall transfer function.
3. Transient and steady state response, time domain specifications and the concept of Root loci.
4. Frequency domain specifications, Bode diagrams and Nyquist plots.
5. State space modelling of Control system

UNIT-I

Control Systems Concepts: Open loop and closed loop control systems and their differences- Examples of control systems- Classification of control systems, Feedback characteristics, Effects of positive and negative feedback, Mathematical models – Differential equations of translational and rotational mechanical systems and electrical systems, Analogous Systems, Block diagram reduction methods – Signal flow graphs - Reduction using Mason's gain formula. Principle of operation of DC and AC Servo motor, Transferfunction of DC servo motor - AC servo motor, Synchros.

Learning Outcomes:

At the end of the unit, the student will be able to

- Write the differential equations for mechanical and electrical systems.
- Obtain the transfer function from block diagrams, servo motors and signal flow graphs.

UNIT-II

Time Response Analysis: Step Response - Impulse Response - 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, Study of effects and Design of P, PI, PD and PID Controllers on second order system.

Learning Outcomes:

At the end of the unit, the student will be able to

- Analyze the time domain specifications.
- Calculate the steady state errors.
- Understand about Proportional, Integral and Derivative controllers along with combinations.

UNIT III

Stability Analysis in Time Domain: The concept of stability – Routh's stability criterion – Stability and conditional stability - limitations of Routh's stability. The Root locus concept- construction of root loci-effects of adding poles and zeros to $G(s)H(s)$ on the rootloci.

Learning Outcomes:

At the end of the unit, the student will be able to

- Analyze the concept of stability in time domain
- Apply the concept of Routh's stability and Root locus in time domain

UNIT-IV

Frequency Response Analysis: Introduction, Frequency domain specifications-Bode diagrams-Determination of Frequency domain specifications and transfer function from the Bode Diagram-Stability Analysis from Bode Plots. Polar Plots-Nyquist Plots- Phase margin and Gain margin-Stability Analysis.

Compensation techniques – Study of Effects and Design of Lag, Lead, Lag-Lead Compensator design in frequency Domain on a second order system.

Learning Outcomes:

At the end of the unit, the student will be able to

- Evaluate the frequency domain specifications from Bode, Polar and Nyquist plots
- Design Compensators for various systems
- Deducing transfer functions from Bode Plots
- Understand difference between Phase and Gain margins

UNIT-V

State Space Analysis of Continuous Systems: Concepts of state, state variables and state model - differential equations & Transfer function models - Block diagrams. Diagonalization, Transfer function from state model, solving the Time invariant state Equations- State Transition Matrix and its Properties. System response through State Space models. The concepts of controllability and observability, Duality between controllability and observability.

Learning Outcomes:

At the end of the unit, the student will be able to

- Understand the concept of state space, controllability and observability
- Obtain the transfer function from state space and vice versa
- Understand the state transition method of solving time invariant state equations

TEXTBOOKS:

1. Modern Control Engineering by Katsuhiko Ogata, Prentice Hall of India Pvt. Ltd., 5th edition, 2010.

2. Control Systems Engineering by I. J. Nagrath and M. Gopal, New Age International (P) Limited Publishers, 5th edition, 2007.

REFERENCE BOOKS:

1. Control Systems Principles & Design by M. Gopal, 4th Edition, McGraw Hill Education, 2012.
2. Automatic Control Systems by B. C. Kuo and Farid Golnaraghi, John Wiley and Sons, 8th edition, 2003.
3. Feedback and Control Systems, Joseph J. Distefano III, Allen R. Stubberud & Ivan J. Williams, 2nd Edition, Schaum's Outlines, McGraw Hill Education, 2013.
4. Control System Design by Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado, Pearson, 2000.
5. Feedback Control of Dynamic Systems by Gene F. Franklin, J.D. Powell and Abbas Emami-Naeini, 6th Edition, Pearson, 2010.

COURSE OUTCOMES:

After completing the course, the student should be able to:

1. Understand the concepts of control systems classification, feedback effect, mathematical modelling, time response and frequency response characteristics, state space analysis
2. Apply the concepts of Block diagram reduction, Signal flow graph method and state space formulation for obtaining mathematical and Root locus, Bode, Nyquist, Polar plots for stability calculations, controllability and observability and demonstrate the use of these techniques.
3. Analyse time response analysis, error constants, and stability characteristics of a given mathematical model using different methods.
4. Design and develop different compensators, controllers and their performance evaluation for various conditions. Implement them in solving various engineering applications.

