

7 th Semester	REL7D001	Advance Control System	L-T-P 3-0-0	3 Credits
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Module I:**(12 hours)**

Discrete - Time Control Systems:

Introduction: Discrete Time Control Systems and Continuous Time Control Systems, Sampling Process. Digital Control Systems: Sample and Hold, Analog to digital conversion, Digital to analog conversion. The Z-transform: Discrete-Time Signals, The Z-transform, Z-transform of Elementary functions, Important properties and Theorems of the Z-transform. The inverse Z-transform, Z-Transform method for solving Difference Equations. Z-Plane Analysis of Discrete Time Control Systems: Impulse sampling & Data Hold, Reconstruction of Original signals from sampled signals: Sampling theorem, folding, aliasing. Pulse Transfer function: Starred Laplace Transform of the signal involving Both ordinary and starred Laplace Transforms; General procedures for obtaining pulse Transfer functions, Pulse Transfer function of open loop and closed loop systems. Mapping between the s-plane and the z-plane, Stability analysis of closed loop systems in the z-plane: Stability analysis by use of the Bilinear Transformation and Routh stability criterion, Jury's stability Test

Module II:**(12 hours)**

State Variable Analysis & Design:

Introduction: Concepts of State, State Variables and State Model (of continuous time systems): State Model of Linear Systems, State Model for Single-Input-Single-Output Linear Systems, Linearization of the State Equation. State Models for Linear Continuous – Time Systems: State-Space Representation Using Physical Variables, State – space Representation Using Phase Variables, Phase variable formulations for transfer function with poles and zeros, State – space Representation using Canonical Variables, Derivation of Transfer Function for State Model. Diagonalization: Eigenvalues and Eigenvectors, Generalized Eigenvectors. Solution of State Equations: Properties of the State Transition Matrix, Computation of State Transition Matrix, Computation by Techniques Based on the Cayley-Hamilton Theorem, Sylvester's Expansion theorem. Concepts of Controllability and Observability: Controllability, Observability, Effect of Pole-zero Cancellation in Transfer Function. Pole Placement by State Feedback, Observer Systems. State Variables and Linear Discrete – Time Systems: State Models from Linear Difference Equations/z-transfer Functions, Solution of State Equations (Discrete Case), An Efficient Method of Discretization and Solution, Linear Transformation of State Vector (Discrete-Time Case), Derivation of z-Transfer Function from Discrete-Time State Model.

Module III:**(12 hours)**

Nonlinear Systems:

Introduction: Behaviour of Nonlinear Systems, Investigation of nonlinear systems. Common Physical Non Linearities: Saturation, Friction, Backlash, Relay, Multivariable Nonlinearity. The Phase Plane Method: Basic Concepts, Singular Points: Nodal Point,

Saddle Point, Focus Point, Centre or Vortex Point, Stability of Non-Linear Systems: Limit Cycles, Construction of Phase Trajectories: Construction by Analytical Method, Construction by Graphical Methods. The Describing Function Method: Basic Concepts: Derivation of Describing Functions: Dead-zone and Saturation, Relay with Dead-zone and Hysteresis, Backlash. Stability Analysis by Describing Function Method: Relay with Dead Zone, Relay with Hysteresis, Stability Analysis by Gain-phase Plots. Jump Resonance. Liapunov's Stability Analysis: Introduction, Liapunov's Stability Criterion: Basic Stability Theorems, Liapunov Functions, Instability. Direct Method of Liapunov & the Linear System: Methods of constructing Liapunov functions for Nonlinear Systems.

Books:

- [1] *Discrete-Time Control System*, by K.Ogata, 2nd edition (2009), PHI.
- [2] *Control Systems Engineering*, by I.J. Nagrath and M.Gopal, 5th Edition (2007 / 2009), New Age International (P) Ltd. Publishers.
- [3] *Control Systems (Principles & Design)* by M.Gopal, 3rd Edition (2008), Tata Mc.Graw Hill Publishing Company Ltd.
- [4] *Design of Feedback Control Systems* by Stefani, Shahian, Savant, Hostetter, Fourth Edition (2009), Oxford University Press.
- [5] *Modern Control Systems* by K.Ogata, 5th Edition (2010), PHI.
- [6] *Modern Control Systems* by Richard C. Dorf. And Robert, H.Bishop, 11th Edition (2008), Pearson Education Inc. Publication.
- [7] *Design of Feedback Control Systems* by Stefani, Shahian, Savant, Hostetter, Fourth Edition (2009), Oxford University Press.

Digital Learning Resources:

Course Name: Advanced Linear Continuous Control Systems: Applications with MATLAB Programming and Simulink
 Course Link: <https://nptel.ac.in/courses/108/107/108107115/>
 Course Instructor: Prof. Yogesh Vijay Hote, IIT Roorkee