**SYLLABUS**

**SUBJECT NAME: CONTROL SYSTEMS=II (3-0-0)**

**CODE: UPEEE703**

**COURSE OUTCOMES:**

At the end of this course, students will demonstrate the ability to

* Obtain discrete representation of LTI systems.
* Analyse stability of open loop and closed loop discrete-time systems.
* Design and analyse digital controllers.
* Learn about analysis of Non-Linear Systems

**CO-PO-PSO MAPPING:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Outcomes**  **(CO)** | **Programme Outcomes (PO)** | | | | | | | | | | | | **Programme Specific Outcomes**  **(PSO)** | |
| PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO  10 | PO  11 | PO  12 | PSO1 | PSO2 |
| CO1 | **2** | **3** | **2** | **3** | **3** | **1** | **-** | **-** | **-** | **2** | **2** | **3** | **3** | **3** |
| CO2 | **2** | **3** | **2** | **2** | **3** | **1** | **-** | **-** | **2** | **2** | **2** | **3** | **3** | **3** |
| CO3 | **2** | **3** | **3** | **3** | **3** | **1** | **1** | **-** | **2** | **2** | **2** | **3** | **3** | **3** |
| CO4 | **2** | **3** | **1** | **1** | **2** | **1** | **-** | **-** | **-** | **2** | **1** | **2** | **3** | **3** |

**Module-I Discrete - Time Control Systems:** **[10 Hours]**

Introduction: Discrete Time Control Systems and Continuous Time Control Systems, Sampling Process. Sample and Hold, 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 stability Test

**Module-II State Space Approach for discrete time systems (8 hours)**

State space models of discrete systems, State space analysis. Lyapunov Stability, Controllability, observability analysis. Effect of pole zero cancellation on the controllability & observability.

**Module-III Nonlinear Systems: [12 Hours]**

Introduction, Common Physical Non-linearities, The Phase-plane Method: Basic Concepts, Singular Points, Stability of Nonlinear System, Construction of Phase-trajectories, The Describing Function Method: Basic Concepts, Derivation of Describing Functions, Stability analysis by Describing Function Method, Jump Resonance, Signal Stabilization.

Liapunov’s Stability Analysis: Introduction, Liapunov’s Stability Criterion, The Direct Method of Liapunov and the Linear System, Methods of Constructing Liapunov Functions for Nonlinear Systems

**Text Books :**

1. K. Ogata, “Digital Control Engineering”, Prentice Hall, Englewood Cliffs, 1995.

2. M. Gopal, “Digital Control Engineering”, Wiley Eastern, 1988.

3. G. F. Franklin, J. D. Powell and M. L. Workman, “Digital Control of Dynamic Systems”, Addison-Wesley, 1998.

4. B.C. Kuo, “Digital Control System”, Holt, Rinehart and Winston, 1980.

5. H.K. Khallil, Non Linear Systems, 3rd edition (2002), Pearson Education

1. B. Friedland, Control System Design - An Introduction to State-Space Methods, McGraw-Hill, 2007
2. S.H. Zak, Systems and Control, Oxford Univ. Press, 2003

**LESSON PLAN**

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| DAY NO. | PROPOSED TOPICS TO BE TAUGHT |
|  | Introduction to discrete-time control systems |
|  | Z- Transform |
|  | Inverse Z-Transform |
|  | Problem Solving on the above topics (Problem Solving Class-I) |
|  | Impulse Sampling and Data Hold |
|  | Reconstruction of Signals |
|  | Pulse Transfer Function |
|  | Mapping between S-Plane and Z-Plane |
|  | Stability Analysis of Closed Loop Systems |
|  | Problem Solving on the above topics (Problem Solving Class-II) |
|  | State Space Representation of Discrete-time systems (Controllable and Observable Cannonical forms) |
|  | State Space Representation of Discrete-time systems (Diagonal and Jordan Cannonical forms), Signal Flow Graph representation |
|  | Similarity Transformation, State-space to Transfer Function conversion, Characteristic Equation |
|  | Problem Solving on the above topics (Problem Solving Class-III) |
|  | Lyapunov Stability Analysis of Continuous-time systems |
|  | Liapunov’s Stability Criterion, The Direct Method of Liapunov and the Linear System, |
|  | Controllability and Observability – Definitions and Conditions |
|  | Pole Placement Method, Determination of Feedback gain Matrix K by different methods |
|  | Full order Observer, Determination of Observer gain Matrix L by different methods |
|  | Problem Solving on the above topics (Problem Solving Class-IV) |
|  | Introduction to Non-linear systems, Difference between linear and non-linear systems, Common Physical Non-linearities, |
|  | The Phase-plane Method: Basic Concepts, Singular Points |
|  | Describing Function Method: Basic Concepts |
|  | Derivation of Describing Functions for Relay with Dead zone and Saturation non-linearities, |
|  | Derivation of Describing Functions for Relay with Dead zone and Hysterisis non-linearities, Backlash Non-linearity |
|  | Definition, Prediction and Stability of Limit Cycle |
|  | Stability analysis by Describing Function Method for systems controlled by ideal relay and Relay with Dead zone |
|  | Jump Resonance |
|  | Problem Solving on the above topics (Problem Solving Class-V) |
|  | Doubt Clearance Class |