

ECPE3012 ADVANCED CONTROL SYSTEM (3-0-0)

Course Objectives :

- To introduce the continuous time linear and nonlinear systems in state space framework.
- To model and discuss performance, stability of discrete data systems.
- To give basic knowledge in describing function analysis.
- To provide knowledge in phase plane analysis.
- To study the design of Sliding mode control
- To study the design of Optimal control

Module I (8 Hours)

Introduction to State-Space

Introduction of State-Space, State-Space representation in Canonical forms: Diagonal, Controllable, Observable, & Jordan Diagonal canonical form. Conversions between State Space and Transfer Functions model. State transition matrix, solution of Homogeneous and Non-homogeneous State equation of continuous time invariant systems. Concepts of Controllability, Observability, Stabilizability & Detectability. Design of state variable feedback, Regulator design via pole placement method, determination of full state feedback gain using Direct comparison method, controllable canonical form method.

Module II (8 Hours)

Sampling and Signal reconstruction : Definition and Evaluation of Z-Transform, properties of Z-Transform, Inverse Z-Transform, Mapping between S-plane and Z-plane, system descriptions by difference equations and solutions.

Sample data control systems : transfer function of discrete data systems, Pulse and Z-Transform functions, transfer function of discrete data systems with cascade elements, transfer functions of Zero order and 1st order holds, transfer function of closed loop discrete data systems, State equation of discrete data systems, solution of discrete state equations, discrete state transition equation, Z-Transform solutions of discrete equations, Transfer function matrix and the Characteristics equation, stability Tests of discrete state equations, Bilinear Transformation method, direct stability Tests.

Module III (5 Hours)

Nonlinear systems : Common physical nonlinearities, the phase plane methods, Basic concepts, Singular points, stability on nonlinear systems, Construction of phase trajectories, Construction by analytical and graphical methods, System analysis by phase plane method,

The describing function methods : Basic concepts, derivation of describing functions for common nonlinearities, stability analysis by Describing function approach, Jump resonance, Lyapunov stability criterion, Popov's stability criterion.

Module IV (4 Hours)

Sliding Mode Control

Sliding surfaces, Filippov's construction of the equivalent dynamics, direct implementations of switching control laws, continuous approximations of switching control laws, modeling/performance trade-offs.

Module V (5 Hours)

Optimal Control

Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Riccati's equation – Application examples.

Kalman Bucy Filter-Solution by duality principle-Discrete systems- Kalman Filter-Application examples

Course Outcomes (CO): On completion of this course, students are able to:

CO1 Able to acquire knowledge about continuous time systems and nonlinear systems in state space and their applications

- CO2. Able to obtain the mathematical models and analysis of discrete data systems.
- CO3. Able to carry out analysis for common nonlinearities in a system.
- CO4. Able to design Sliding mode controller.
- CO5. Understand the basics and Importance of Kalman filter.

Text Book(s):

- 1. K. Ogata, "Modern Control Engineering", Pearson Education India, 5th Edition, 2015.
- 2. I. J. Nagrath, M. Gopal, "Control System Engineering", New Age International, 6th Edition, 2017.
- 3. H. J. Marquez, "Nonlinear Control Systems: Analysis and Design", John Wiley Interscience, 2nd Edition, 2003.
- 4. J. E. Slotine and W. Li, "Applied nonlinear control", Prentice Hall, 1st Edition, 1991.

Reference Book(s):

- 1. N. S. Nise, "Control System Engineering", Wiley India, 5th Edition, 2009.
- 2. F. Golnaraghi, B. C. Kuo, "Automatic Control Systems", Wiley India, 9th Edition, 2014.
- 3. H. K. Khalil., "Nonlinear Systems", Prentice Hall, 3rd Edition, 2014.