EE 517: NONLINEAR SYSTEMS AND CHAOS (3-0-0:3)

Introduction to dynamical systems

Representations of dynamical systems, Vector fields of nonlinear systems, Limit cycles, Nonlinear systems and their classification, Existence and uniqueness of solutions, Fixed points and Linearization, Stability of equilibria, Conservative and reversible systems.

Tools for detecting chaos

Phase plane, Stable and unstable manifolds, Saddle-node, Transcritical, Pitchfork bifurcations, Hopf bifurcation, Global bifurcations, Center manifold theory and Poincare maps, Lyapunovexponents, Power spectrum, Frequency spectra of orbits, Dynamics on a torus, Analysis of chaotic time series.

Introduction to chaotic/hyperchaotic systems

Logistics map, Forced pendulum and Duffing oscillator, Lorenz system, Rosslersystem, Chua's circuit, Strange attractors, Systems with hidden attractors, Discrete time dynamical systems.

Chaos control and its application

Need for chaos control, The OGY method, PC method, Optimal control, Adaptive control, Feedback control, Application in Physics (Laser and Plasma),Electrical (Electrical drive/power systems), Electronic systems and Communication systems.

Chaos synchronization and its application

Types and method of synchronization, Synchronization in complex systems, Synchronization techniques: Active, Adaptive, Sliding Mode and Optimal control, Chaos synchronization based secure communication.

Suggested List of Experiments

1. To familiarize the dynamical systems in MATLAB using ODE45
2. To study and plot the different singular points.
3. To analyze the phase portraits for nonlinear pendulum with and without friction.
4. To plot the strange attractors of Lorenz, Rossler, Chua's chaotic systems/oscillators.
5. Circuit design of Lorenz and Rosslerchaotic systems using PSpice/ Multisim.
6. Circuit implementation of Lorenz and Rosslerchaotic systems using PSpice/ Multisim.
7. Circuit design and implementation for chaos control.
8. Circuit design and implementation of chaos control and its application.
9. Circuit design and implementation for chaos synchronization.
10. Circuit design and implementation of chaos synchronization and its application.

Text Books and References:

1. H. K.Khalil,"Nonlinear Systems", 2nd edition, Prentice Hall, New Jersey, 1996.
2. H. J. Marquez, "Nonlinear Control Systems: Analysis and Design", John Wiley Interscience, 2003.
3. S. Strogatz, "Nonlinear Dynamics and Chaos", MA: Addison-Wesley, 1994.
4. G. Chen, X. Dong, "From Chaos to Order", World Scientific, Singapore, 1998.
5. K.T. Alligood et al., "Chaos: An Introduction to Dynamical Systems", Springer, 1996.
6. Ott Edward, "Chaos in Dynamical systems", 2nd edition. Cambridge, UK, 2002.

7. J. Guckenheimer, and P. Holmes, “Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields”, New York,Springer-Verlag, 2002.
8. T. S. Parker and L. O. Chua, “Practical Numerical Algorithms for Chaotic Systems”, New York,Springer-Verlag,1991.