ABSTRACT

The thesis presents the study of bifurcations, stochastic resonance, computation and communication aspects of certain simple chaotic circuits and systems. The study of simple third-order autonomous systems with one of four different nonlinear functions $x^2$, $|x|$, max (x), and min (x) as the only nonlinearity in the system has been considered. Further, based on this, new chaotic second-order non-autonomous systems with the same nonlinearities $x^2$, $|x|$, max(x) and min(x) have been constructed. Suitable numerical and experimental studies have been made along with characterization of chaos through Lyapunov exponents.

Then, the chaotic dynamics of simple second-order non-autonomous systems with a new type of nonlinearity being realized with a threshold controller has been considered and studied both numerically and experimentally. The characterization of strong and weak chaos using probability distribution and statistical based test for this second-order non-autonomous system with threshold controller have been studied. The strong chaos is evidenced by the high value of the largest positive Lyapunov exponent and weak chaos is by small positive Lyapunov exponent. Stationary distribution occurs for strong chaos and non-stationary distribution for weak chaos. The $\chi^2$ test has also been performed numerically to ascertain the distribution nature of state variables of this chaotic system.
Further, the applications of chaotic systems in the field of stochastic resonance, computation and communication aspects have been considered. The stochastic resonance phenomenon occurring in simple second-order system with threshold controller subjected to the periodic forcing and Gaussian noise has been considered and the response of the system to the external periodic sinusoidal forcing has been studied both numerically and experimentally with ‘noise free’ and with noise conditions for different intensities. The occurrence of stochastic resonance behavior is characterized by signal-to-noise ratio (SNR), response amplitude and normalized residence time distribution.

Then, a new simple experimental realization of the chaos computing scheme by directly implementing the fundamental NOR gate with a continuous time simple analog simulation type chaotic circuit using control method has been described and this experiment constitutes a proof-of-principle demonstration of the universal computing capability of chaotic circuits. The same approach has been applied to the familiar Lorenz system to emulate NOR logic operation numerically by controlling two state variables separately. Further, by considering two such systems in the form of cross-coupled version, a novel way of achieving a chaotic scheme based sequential gate i.e., a SR flip-flop operation has been obtained and the results have been presented with suitable numerical simulation timing waveforms.

Finally, a novel Ergodic Chaotic On-Off Keying (E-COOK) based digital spread spectrum communication scheme has been introduced. In this scheme, a simple chaos on-off keying method is utilized at the transmitter. A novel approach called as the mean-value estimation
method, is adopted to propose a non-coherent demodulator design for chaos based digital communication scheme. Further spread spectrum image encoding and decoding simulation results have been given.