

PREFACE

Nonlinear circuits and systems, such as electronic circuits (Chapter 5), power converters (Chapter 6), human brains (Chapter 7), phase lock loops (Chapter 8), sigma delta modulators (Chapter 9), etc, are found almost everywhere. Understanding nonlinear behaviours as well as control of these circuits and systems are important for real practical engineering applications.

Control theories for linear circuits and systems are well developed and almost complete. However, different nonlinear circuits and systems could exhibit very different behaviours. Hence, it is difficult to unify a general control theory for general nonlinear circuits and systems. Up to now, control theories for nonlinear circuits and systems are still very limited. The objective of this book is to review the state-of-the-art chaos control methods for some common nonlinear circuits and systems, such as those listed in the above, and stimulate further research and development in chaos control for nonlinear circuits and systems.

This book consists of three parts. The first part of the book consists of reviews on general chaos control methods. In particular, a time-delayed approach written by H. Huang and G. Feng is reviewed in Chapter 1. A master slave synchronization problem for chaotic Lur'e systems is considered. A delay independent and delay dependent synchronization criteria are derived based on the H_∞ performance. The design of the time delayed feedback controller can be accomplished by means of the feasibility of linear matrix inequalities. In Chapter 2, a fuzzy model based approach written by H.K. Lam and F.H.F. Leung is reviewed. The synchronization of chaotic systems subject to parameter uncertainties is considered. A chaotic system is first represented by the fuzzy model. A switching controller is then employed to synchronize the systems. The stability conditions in terms of linear matrix inequalities are derived

based on the Lyapunov stability theory. The tracking performance and parameter design of the controller are formulated as a generalized eigenvalue minimization problem which is solved numerically via some convex programming techniques. In Chapter 3, a sliding mode control approach written by Y. Feng and X. Yu is reviewed. Three kinds of sliding mode control methods, traditional sliding mode control, terminal sliding mode control and non-singular terminal sliding mode control, are employed for the control of a chaotic system to realize two different control objectives, namely to force the system states to converge to zero or to track desired trajectories. Observer based chaos synchronizations for chaotic systems with single nonlinearity and multi-nonlinearities are also presented. In Chapter 4, an optimal control approach written by C.Z. Wu, C.M. Liu, K.L. Teo and Q.X. Shao is reviewed. Systems with nonparametric regression with jump points are considered. The rough locations of all the possible jump points are identified using existing kernel methods. A smooth spline function is used to approximate each segment of the regression function. A time scaling transformation is derived so as to map the undecided jump points to fixed points. The approximation problem is formulated as an optimization problem and solved via existing optimization tools.

The second part of the book consists of reviews on general chaos controls for continuous-time systems. In particular, chaos controls for Chua's circuits written by L.A.B. Tôrres, L.A. Aguirre, R.M. Palhares and E.M.A.M. Mendes are discussed in Chapter 5. An inductorless Chua's circuit realization is presented, as well as some practical issues, such as data analysis, mathematical modelling and dynamical characterization, are discussed. The tradeoff among the control objective, the control energy and the model complexity is derived. In Chapter 6, chaos controls for pulse width modulation current mode single phase H-bridge inverters written by B. Robert, M. Feki and H.H.C. Iu are discussed. A time delayed feedback controller is used in conjunction with the proportional controller in its simple form as well as in its extended form to stabilize the desired periodic orbit for larger values of the proportional controller gain. This method is very robust and easy to implement. In Chapter 7, chaos controls for epileptiform bursting in the brain written by M.W. Słutsky, P. Cvitanovic and D.J. Mogul are

discussed. Chaos analysis and chaos control algorithms for manipulating the seizure-like behaviour in a brain slice model are discussed. The techniques provide a nonlinear control pathway for terminating or potentially preventing epileptic seizures in the whole brain.

The third part of the book consists of reviews on general chaos controls for discrete-time systems. In particular, chaos controls for phase lock loops written by A.M. Harb and B.A. Harb are discussed in Chapter 8. A nonlinear controller based on the theory of backstepping is designed so that the phase lock loops will not be out of lock. Also, the phase lock loops will not exhibit Hopf bifurcation and chaotic behaviours. In Chapter 9, chaos controls for sigma delta modulators written by B.W.K. Ling, C.Y.F. Ho and J.D. Reiss are discussed. A fuzzy impulsive control approach is employed for the control of the sigma delta modulators. The local stability criterion and the condition for the occurrence of limit cycle behaviours are derived. Based on the derived conditions, a fuzzy impulsive control law is formulated so that the occurrence of the limit cycle behaviours, the effect of the audio clicks and the distance between the state vectors and an invariant set are minimized supposing that the invariant set is nonempty. The state vectors can be bounded within any arbitrary nonempty region no matter what the input step size, the initial condition and the filter parameters are.

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