

RESEARCH AREAS

Nonlinear Dynamical Systems (chaos and memristor modeling), Embedded Systems, Education

QUALIFICATIONS

- **PhD in Electrical Engineering,**
December 2009, University of California, Berkeley
Thesis: Contributions to the Study of Autonomous Chaotic Circuits and Cellular Automata
Concentration: Nonlinear Dynamical Systems
Dissertation Committee: Dr. Leon Chua (advisor), Dr. Pravin Varaiya and Dr. Andrew Szeri
- **MS in Electrical Engineering,**
May 2005, University of California, Berkeley
Thesis: Implementing Central Pattern Generators for Bipedal Walkers Using CNN
Concentration: Robotics, Neural Networks and Nonlinear control/circuits
Advisor: Dr. Leon Chua
- **BS in Electrical Engineering (Honors),**
August 2002, University of California, Berkeley
Concentration: Circuits and Systems

SCIENTIFIC CONTRIBUTIONS

- **Systematically designed the Muthuswamy-Chua system (circuit)**
Sample reference(s):
 1. “On the amplitude of external perturbation and the chaos via devil’s staircase in the Muthuswamy-Chua System”, Furui, S. and Takano, T. To appear in the International Journal of Bifurcation and Chaos, 2015.
 2. “Computer Assisted Proof of Chaos in the Muthuswamy-Chua Memristor Circuit”, Galias, Z. Invited Paper – Nonlinear Theory and Its Applications, IEICE, vol. 5, no. 3, pp. 309 – 319. DOI: 10.1588/nolta.5.309, 2014.
 3. “Novel Chaotic Behaviour in the Muthuswamy-Chua System Using Chebyshev Polynomials”, Teng, L. et. al. To appear in the International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, 2014. DOI: 10.1002/jnm.2014
 4. “Dynamics of the Muthuswamy-Chua system”, Wang, Z. and Zhang, X. International Journal of Bifurcation and Chaos, 23(8), pp. 1350136-1350143, August 2013.
 5. “On the Integrability of a Muthuswamy-Chua System”, Llibre, J. and Valls, C. Journal of Nonlinear Mathematical Physics, 19(4), pp. 1250029-1250041, December 2012.

AWARDS

- 2014 Visiting Faculty, Institute of Advanced Studies, University of Western Australia
- Finalist, 2013 & 2014 Falk Engineering Educator Award, Milwaukee School of Engineering
- 2010 Faculty Endowment Award, Milwaukee School of Engineering
- 2009 New Kind of Science Summer School Fellow, CNR-Istituto ISTI, Pisa, Italy
- Lecturer Teaching Fellow, 2008 – 2009, University of California, Berkeley
- EECS Department GSR Fellowship, Spring 2008, University of California, Berkeley
- Research Mentor Award, Summer 2007, University of California, Berkeley LEADS
- Outstanding GSI Award, 2006 – 2007, University of California, Berkeley

COMPUTING SKILLS

- Mathematical packages: MATLAB, Simulink, Mathematica
- Simulation Tools: MultiSim, ModelSim

- Hardware Description Language: Verilog, VHDL
- Programming Languages: C, C++, JavaScript, Python, LABVIEW
- Operating Systems: Linux, OS X
- Hardware Platforms: Microcontrollers and FPGAs [Altera Cyclone, Stratix]

EMPLOYMENT

- **Software Engineer**
June 2015 - Present
Tarana Wireless
Santa Clara, California, USA
 - Work on various subsystems for implementing non-line of sight (NLOS) communication (2.4 GHz, 3.6 GHz, 5.8 GHz) systems. Tasks:
 - Design and debug various SNMP modules for Gen2 and Gen3 platforms
 - Implement test framework for validating various subsystems
 - Implement dynamic frequency selection (DFS) for ensuring systems are radar compliant in unlicensed 5.8 GHz band(s) (ETSI, FCC)
 - Design a JavaScript monitoring tool for use by employees and customers
- **Embedded Systems R&D Engineer**
August 2008 – August 2009
Electronics Support Group
University of California, Berkeley
 - Designed an analog LED driver for interfacing with various 5 V and 3.3 V sensors in EE100 (Introduction to Electronics) at the University of California, Berkeley
 - Debugged analog magnetic levitation controller for use in EE128 (Feedback Systems Design) at the University of California, Berkeley
 - Configured Quanser Self Erecting Inverted Pendulum setups for use in EE128

RESEARCH

- **Assistant Professor of Electrical Engineering**
September 2009 – June 2015
Milwaukee School of Engineering, Milwaukee, WI
 - Investigate mathematical properties, circuit realizations and applications of memristors
 - Understand chaotic dynamics of the Muthuswamy-Chua system
 - Design field-programmable gate array (FPGA) subsystems for hardware emulation of nonlinear dynamics
- **Graduate Student Researcher**
January 2005 – December 2009
Nonlinear Electronics Laboratory, University of California, Berkeley
<http://nonlinear.eecs.berkeley.edu>
 - Proved that the 4 Element Chua's circuit is chaotic via Shilnikov's theorem
 - Investigated and implemented memristor based chaotic systems
 - Researched the relationship between Cellular Automata and Fermat Numbers
 - Designed and maintained website for the Nonlinear Electronics laboratory
 - Designed an XY mode add-on (using Qt) to osqoop, a sound-card based scope
 - Studied the use of Central Pattern Generators (CPGs) in bipedal walking
- **Graduate Student Researcher**
January 2007 – December 2007
Connectivity Laboratory, University of California, Berkeley
<http://connectivitylab.eecs.berkeley.edu>
 - Worked on implementing Software Defined Radio (802.11) on DN8000k10PCI

- **Graduate Student Researcher**
December 2003 – November 2004
Berkeley Aerobots (BEAR), University of California, Berkeley
 - Studied the feasibility of upgrading control computer OS on BEAR helicopters from QNX 4.2 to QNX 6.2.1

EDUCATION

- **Assistant Professor of Electrical Engineering**
September 2009 – June 2015
Milwaukee School of Engineering, Milwaukee, WI
 - Prepare lecture notes, teach courses and grade student assignments in control theory, digital logic and basic electronics.
 - Workload of 3 courses per quarter, with an average of 20 students per course.
 - Approximately 20 in-class teaching hours per week.
- **Visiting Lecturer and Graduate Student Instructor**
September 1999 – September 2008
University of California, Berkeley
 - Prepared lecture notes for classes of approximately 100 students in topics on basic linear and nonlinear circuit analysis, control theory and systems theory
 - Assisted students in applying circuit analysis techniques to understand linear (resistive, capacitive and amplifier) circuits and nonlinear (diodes, oscillator) circuits
 - Coordinated teaching assistants and readers to ensure smooth operation of courses
 - Developed exercises using MATLAB and Simulink to illustrate concepts covered in lecture
 - Redesigned various laboratory experiments in different courses to coordinate closely with lecture material

PUBLICATIONS

- **A Route to Chaos Using FPGAs – Volume II : Theoretical Methods.** Muthuswamy, B. and Banerjee, S. *Book to be published by Springer-Verlag under series Emergence, Complexity and Computation, 2016-2017.*
- **A Route to Chaos Using FPGAs – Volume I : Experimental Observations.** Muthuswamy, B. and Banerjee, S. *Springer-Verlag Series on Emergence, Complexity and Computation, 2015.*
Companion website for the book:
<http://www.harpgroup.org/muthuswamy/ARouteToChaosUsingFPGAs/ARouteToChaosUsingFPGAs.html>
- **A Generic Model of Memristors With Parasitic Components.** Sah, M. et. al. *IEEE Transactions on Circuits and Systems I : Regular Papers.* Vol. 62, No 3., pp. 891 – 898, 2015. DOI: 10.1109/TCSI.2014.2373674
- **Memristor Modelling.** Muthuswamy, B. et. al. *Proceedings of the 2014 International Symposium on Circuits and Systems (ISCAS),* pp. 490 – 493, May 2014. DOI: 10.1109/ISCAS.2014.6865179
- **Synchronization in Coupled Time Delayed Systems - Experimental Observations Using Field Programmable Gate Arrays.** Valli, D. et. al. *Eur. Phys. J. Special Topics, 2014.* DOI: 10.1140/epjst/e2014-02144-8
- **Chaotic Behaviour In a Three Element Memristor Based Circuit Using Fourth Order Polynomial and Piecewise-Linear nonlinearity.** McCullough, M. H., Iu, H.H.C and Muthuswamy, B. *Proceedings of the 2013 IEEE ISCAS,* pp. 2743-2746, May 2013, DOI: 10.1109/ISCAS.2013.6572446.
- **Chua's Equation Was Proved to be Chaotic in 2 Years, Lorenz Equation in 36 Years.** Muthuswamy, Bharathwaj. Invited book chapter. *Chaos, CNN, Memristors and Beyond.* World Scientific Publications. 2013.

- **A Mixed Signal EEG Interface for Use In First Year Electronics Courses.** Lee, V. et. al. *Proceedings of the 2012 IEEE ISCAS*, pp. 2689 – 2692, May 2012.
- **From Van der Pol To Chua – An Introduction to Nonlinear Dynamics and Chaos for Second Year Undergraduates.** Ambelang, S. and Muthuswamy, B. *Proceedings of the 2012 IEEE ISCAS*, pp. 2937-2940, May 2012.
- **Two Element Chaotic and Hyperchaotic circuits.** Muthuswamy et. al. *Proceedings of the 4th International Chaotic Circuits and Systems Symposium*, pp. 1 – 10, May 2012.
- **A Framework for Teaching Nonlinear Operational Amplifier Circuits to Junior Undergraduate Electrical Engineering Students.** Muthuswamy, Bharathwaj and Mossbrucker, Joerg. *Proceedings of the American Society of Engineering Education*, June 2010.
- **Simplest Chaotic Circuit.** Muthuswamy, Bharathwaj and Chua, Leon O. *International Journal of Bifurcation and Chaos*. Vol. 20, No. 5, pp. 1567-1580, May 2010.
- **Implementing Memristor Based Chaotic Circuits.** Muthuswamy, Bharathwaj. *International Journal of Bifurcation and Chaos*. Vol. 20, No. 5, pp. 1335-1350, May 2010.
- **Memristor-Based Chaotic Systems.** Muthuswamy, Bharathwaj and Kokate, Pracheta. *IETE Technical Review*. Vol. 26, Issue 6, pp. 415 – 426, Nov-Dec 2009 (**invited paper**).
- **Extracting Optimal CNN Templates for Linearly-Separable Cellular Automata.** Muthuswamy, Bharathwaj and Chang, Jojo. *International Journal of Bifurcation and Chaos*. Vol. 17, No. 3, pp. 749 - 791, March 2007.

WORKSHOPS and TALKS

- **University of Western Australia - MasterClass Lecture on Memristors.** June 6th 2014, Institute of Advanced Studies, University of Western Australia, Perth, Western Australia.
- **How to Think and Learn: An Example Using Maxwell's Equations.** September 5th 2013, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, Enathur, India.
- **Nonlinear Electronics and Applications – One Day Workshop.** Coordinated by Dr. Ganesan and Dr. Muthuswamy. August 31st 2013, Vellore Institute of Technology, Vellore, India.
- **FPGAs: Introduction and Timing Closure of FPGA Designs.** August 30th 2013, Sri Venkateswara College of Engineering and Technology, Chittoor, India.
- **Chaotic Dynamics of the Muthuswamy-Chua System.** August 23rd 2013, Indian Institute of Technology, Chennai, India.
- **Introduction to FPGAs.** Presented at workshop organized by TIFAC-CORE. August 9th 2013, Vellore Institute of Technology, Vellore, India.
- **Chaotic Time Delay Systems, FPGA Realization and Applications to Secure Communications.** Invited Talk, 20th - 22nd December 2012, 1st International Symposium on Chaos, Complexity and Leadership, Ankara, Turkey.
- **Simplest Chaotic Circuit.** Invited Talk, August 27th 2012, Vellore Institute of Technology, Vellore, India.
- **Chaos is Fun.** August 5th 2012, American Mathematical Association Undergraduate MathFest, University of Wisconsin, Madison, U.S.A.

VISITING PROFESSOR APPOINTMENTS

- **Vellore Institute of Technology.** Visiting Professor at TIFAC-CORE. July – September 2014. Responsibilities: Teach EEE 615 (PG Course on ARM Architecture) and conduct research.
- **Institute of Advances Studies, University of Western Australia.** Visiting Professor. June 5th 2014 – June 16th 2014. Conduct research into physical memristors and the Muthuswamy-Chua System.

- **Vellore Institute of Technology.** Visiting Professor at TIFAC-CORE. August – September 2013. Responsibilities: Teach EEE 615 (PG Course on ARM Architecture) and conduct research.

PEER-REVIEW, MEMBERSHIPS and EDITORIAL BOARD(s)

- Asian Journal of Control, Complex Systems, Communications in Nonlinear Science and Numerical Simulation, International Journal of Systems Science, International Journal of Bifurcation and Chaos, IEEE Transactions on Circuits and Systems, IEEE Transactions on Neural Networks, Journal of Circuits, Systems and Signal Processing, Nonlinear Analysis Series B – Real World Applications, Physica Scripta, International Journal of Circuit Theory and Applications
- Assessor, Australian Research Council, 2013-Present.
- Member and webmaster: IEEE Nonlinear Circuits and Systems Committee, 2013-2015.
- US-Expert Panel: Indo-US Collaboration for Engineering Education [IUCEE], 2010-2015.

ALUMNI

- Jason Genz, Michael T. Rajzer, Grace Whitemore and Wyatt Starck, Milwaukee School of Engineering (MSOE), Class of 2016
- Scott Ambelang, MSOE, Class of 2013
Currently with Qualcomm, Inc., San Diego, CA
- Chris Feilbach, MSOE, Class of 2013
Currently with Nvidia, Santa Clara, CA
- Andrew Przybylski, MSOE, Class of 2013
Currently with Johnson Controls, Milwaukee, WI