

Center for Wireless and Microwave Information Systems

Center for Wireless and Microwave Information Systems

**Department of Electrical Engineering
University of South Florida**

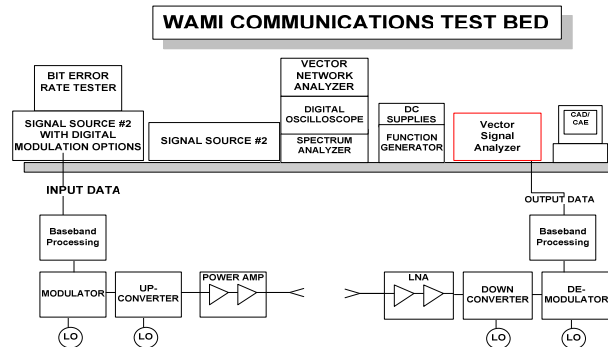
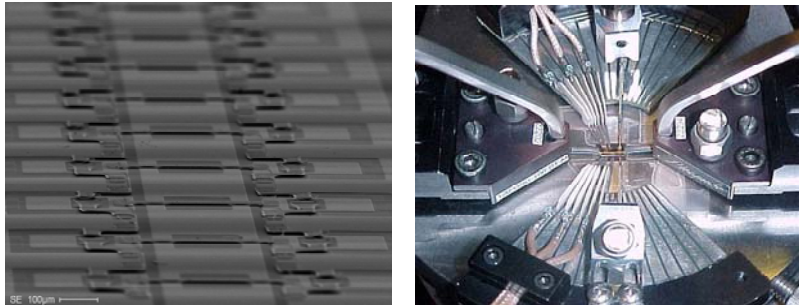
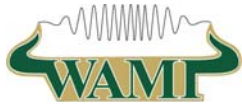
Annual Report 2009

Center Director – Dr. Thomas Weller

**Members: Dr. Adam Anderson, Dr. Huseyin Arslan, Dr. Lawrence Dunleavy, Dr. Rich Gitlin,
Dr. Jing Wang**

Contents:

- **Research Highlights**
- **Selected Curriculum Activities**
- **Professional Activities**
- **Recent Publications**

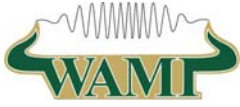


The Center for Wireless and Microwave Information Systems conducts research across a broad range of technical areas that include device modeling and characterization, RF micro electromechanical systems, advanced materials and nanoscale devices, active antennas, cognitive radio and next generation wireless architectures. Research projects focus on basic scientific development as well as applications such as biomedical sensing, communications, robotics and transportation. Active collaborations are pursued with multiple industry and university partners as well as several centers at the University of South Florida.

In 2008/09 the Center will support 34 MS and PhD students and 5 undergraduate students. Center faculty submitted over 25 research proposals in the past year; of these 9 proposals were funded including 3 from government agencies. The WAMI faculty had more than 50 publications in journals, conferences and book chapters.

Newsorthy Notes –

- The **Rudolf E. Henning Distinguished Mentoring Award** was established in 2009 (see following page). Rudy Henning has tirelessly spent his entire career promoting the engineering arts as a profession to students not only at the college level but also at the primary and secondary school levels. The award is co-sponsored by the IEEE WAMICON Organizing Committee and the Florida West Coast Chapter of the Joint IEEE MTT/AP/ED Societies. The recipient of the 2009 award is **Dr. Thomas Brazil**. Dr. Brazil is a noted educator at University College Dublin (UCD). He is a Fellow of the IEEE. He is also Fellow of Engineers Ireland and a Member of highly respected Royal Irish Academy in which he chairs the Science Committee. He has been a tireless, highly



inspirational mentor to countless undergraduate and graduate students in his career spanning well over 30 years.

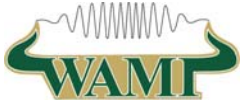
- **The 10th annual IEEE Wireless and Microwave Technology (WAMI) Conference** was held on beautiful Sand Key beach in Clearwater, FL on April 20-21 2009. The conference addresses up-to-date multidisciplinary research needs and interdisciplinary aspects of wireless and RF technology. The IEEE WAMICON conference grew out of a series of very successful 1-day forums organized by the University of South Florida Center for Wireless and Microwave Information Systems faculty, the WAMI Advisory Committee, and the Florida West Coast IEEE MTT/AP/ED chapter. The goal of these conferences and forums is to create a stimulating environment for the exchange of information about the status and directions of wireless technology, the educational and research challenges, and actions being taken by educators, industrial practitioners, and governmental research agencies to address these challenges. The program includes oral presentations, poster presentations, workshops, and tutorials.
- The next WAMI Advisory board meeting will be held in fall 2009. We are currently working on the best date for this event.
- **Gokhan Mumcu**, Ph.D. from The Ohio State University, will join the WAMI Program as an Assistant Professor in fall 2009. Dr. Mumcu's dissertation research was in the area of antenna miniaturization using advanced metamaterial techniques. He is currently appointed in a post-doctoral position, performing research in THz sensing for biomedical applications.
- **Quenton Bonds**, a WAMI Ph.D. student, received a 2009 Graduate Fellowship for Medical Applications from the IEEE MTT Society.
- **Julio Medrano**, a WAMI Ph.D. student, received a Ford Foundation Minority Fellowship.
- Special thanks again to ITT, Raytheon and Mini Circuits other companies for their contributions of financial support, which is used to provide supplemental funds for our students, support conference travel, and allow the WAMI Center to maintain its facilities. The Center also acknowledges the continuing strong support to Agilent Technologies, Ansoft/Ansys, Applied Wave Research and Sonnet for providing our students with access to their exceptional software tools.
- In 2009 the WAMI Advisory Board members contributed \$35,000 to the WAMI Foundation Account, providing much needed discretionary funding to support various center activities. These funds are primarily used for equipment repair/replacement and faculty and student conference travel support. Contributors included Raytheon (\$15K), and ITT (\$20K).
- The new WAMI Center website was launched in early 2009 (<http://wami.eng.usf.edu/>).



The Rudolph Henning Distinguished Mentoring Award

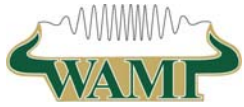
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| Description | To recognize an individual who has performed exemplary service encouraging students and/or mentoring young engineers to advance careers in the areas of RF/Microwave and/or Wireless Engineering |
| Prize | Plaque and Certificate |
| Eligibility and Judging | The selected person will be a current or past member of IEEE whom has had a strong impact on influencing students, young engineers or young faculty members to further their professional careers in the areas of RF/Microwave and/or Wireless Engineering. Factors to be considered are leadership, innovation, dedication, distinguished service and breadth of participation. Eligibility and Selection process shall comply with procedures and regulations established in IEEE and Society governing documents, in particular with IEEE Policy 4.4 on Award Limitations. http://www.ieee.org/web/aboutus/whatis/policies/p4-4.html |
| Presentation | Presented at the annual IEEE WAMICON conference or alternate Florida IEEE event. |
| Sponsorship | Sponsorship by the IEEE Florida West Coast MTT/AP/ED Chapter and the IEEE Florida West Coast Section |
| Selection | Awards Committee as a subset of the the annual IEEE WAMICON Conference Steering Committee in cooperation with the IEEE Florida West Coast Section Awards Committee |





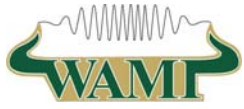
WAMI Center Advisory Board 2009

| Company | Primary Representative | Additional Representatives |
|-----------------------------|------------------------|----------------------------|
| Full Membership | | |
| Agilent Technologies | Craig Sapashe | Eric Schwartz |
| ITT | Mike Wyatt | Larry Geis |
| Raytheon | Al Nauda | Jeff Wunderlich |
| Associate Membership | | |
| Anritsu | Larry Davis | Jon Martens |
| Applied Wave Research | Ted Miracco | Scott Maynard |
| Florida RF Labs | Alen Fejzuli | |
| Freescale | Peter Aaen | John Wood |
| Mini Circuits | Harvey Kaylie | Ted Heil |
| Modelithics | Larry Dunleavy | Rick Connick |
| Guest Membership | | |
| Alliant Techsystems | Jim Culver | |
| Cree | Ray Pengelly | Simon Wood |
| Harris | Rich Abrahams | Joel Johnson, Lester Lopez |
| J-Micro Technologies | Jerry Schappacher | |
| Naval Research Lab | Jean de Graaf | Larry Cohen |
| RFMD | Bill Kopp | |
| Trak | Bill Graves | |
| Triquint | Alex Zajac | Eid Alsabbagh |



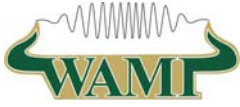
Center for Wireless and Microwave Information Systems

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|------------------------------------------|-------------------|--|
| U.S. Army Comm-Electronics R&D Center | Barry Perlman | |
| University Affiliates | | |
| University of Central Florida | Xun Gong | |
| University of Vermont | Jeff Frolik | |
| Northern Arizona University | Paul Flikkema | |
| Florida State University/FAMU | Mark Weatherspoon | |
| Baylor University | Charles Baylis | |
| Georgia Tech | Steve Kenney | |



Research Highlights – Current & Recent Projects

- **Functional Magnetic Polymer Nanocomposite Films for Tunable RF Device Applications**, P.I. T. Weller, Co-P.I. H. Srikanth and J. Wang, Granting Agency: National Science Foundation. Development of nanocomposite polymer substrates for microwave applications.
- **Non-Linear Device Applications of Nano-Patterned Barium Strontium Titanate Thin Films**, P.I. T. Weller, Co-P.I. A. Kumar and M. Smith (Raytheon), Granting Agency: The National Science Foundation (ECS 0601536). Basic research on the fabrication and characterization of miniaturized non-linear BST microwave devices.
- **Low Cost Omni Antenna**, P.I. T. Weller, Granting Agency: Raytheon. Design of a 4-6 GHz low cost steerable omni-directional antenna.
- **Compact Reconfigurable Channel Emulator**, P.I.: Thomas Weller, Granting Agency: Goodrich. Development a laboratory-scale instrument for characterization of wireless sensor networks.
- **Radiometric Sensors as Non-invasive Approach to Health Monitoring**, P.I. T. Weller, Granting Agency: Raytheon. Analysis and modeling of the dielectric properties of human tissue.
- **NIRT: Nanocrystalline Thin Film Diamond for MEMS and Biomedical Applications**, P.I. Ashok Kumar, Co-PIs: T. Weller, S. Bhansali, and I. Oleynik, Granting Agency: The National Science Foundation. Diamond thin films will be developed for use in high-power, high-reliability RF MEMS phase shifters.
- **Interference Cancellation and Avoidance for OFDM based Future Generation Wireless Cellular Communications Systems**. Huseyin Arslan, Understanding and handling various interference sources in 4-G cellular systems.
- **Introducing Advanced Signal Analysis tools to Spectrum Analyzers**, Huseyin Arslan, Enhancing the spectrum analyzer functionality significantly by introducing advanced time-frequency analysis.
- **Managing and Handling Co-channel Interference in Multi-carrier Signaling Based Broadband Wireless Communication Systems**, Huseyin Arslan, Introducing cognitive networks and adaptive techniques to manage interference in cellular networks.
- **Prediction of Phase Noise in Amplifiers and Frequency Multipliers**, Co-PI and Lead Researcher: C. Baylis, PI: L. Dunleavy. Granting Agency: TRAK Microwave

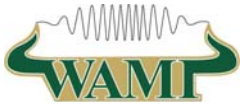


Corporation and Florida High Tech Corridor. Development of a link between modeling of flicker noise and prediction of phase noise through design and measurement of amplifiers and frequency multipliers.

- **Solar-Cell-Microarray-Powered Ultra-High-Q Ultra-High-Frequency (UHF) Nanoprecision Resonator with SWNT as a Platform for Multi-Agent Sensing**, PI: J. Wang, FMMD Seed Grant: Development of a solar-powered microarray of ultra-high-sensitive resonant mass sensors with distinctive binding sites for targeted species as a portable platform for identification of biological/chemical molecular assays.

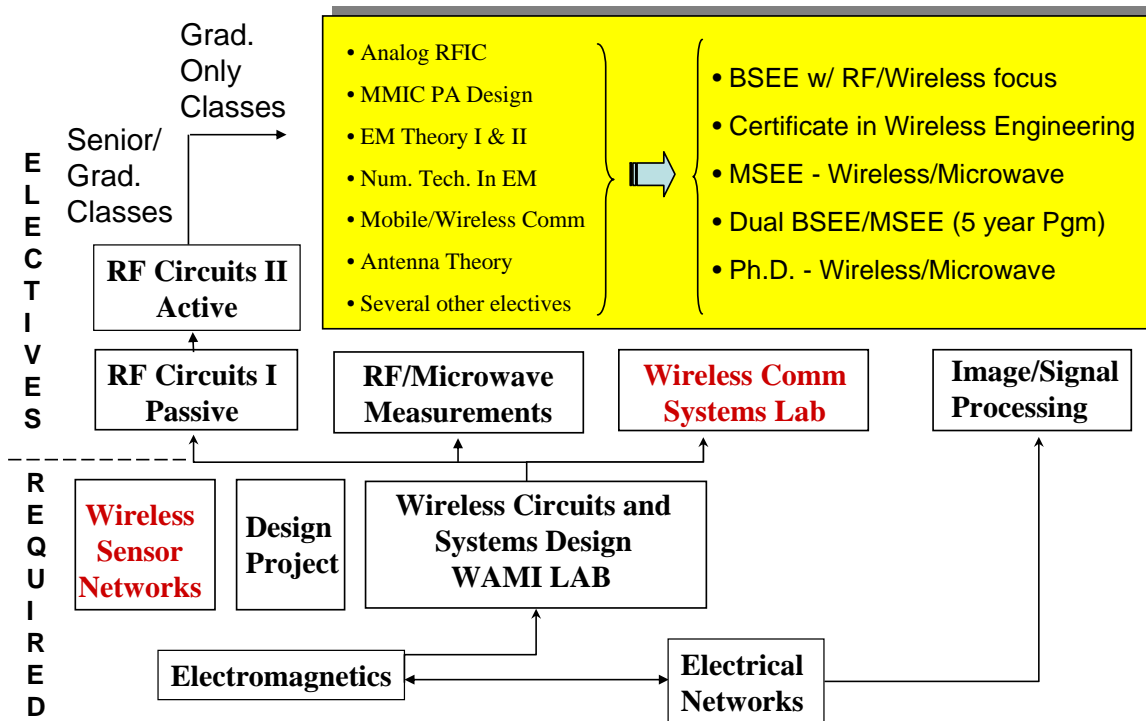
- **Enhanced Characterization Techniques for Transistor and Amplifier Modeling**, PI: J. Wang, Granting Agency: Modelithics, Inc. and Florida High Tech Corridor. Research and training grant for development and verification of improved models as well as modeling and characterization techniques for for high frequency transistors.

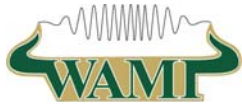
- **Uncooled Nanoscale Infrared High-Speed Sensors for Missile Seeker Applications**, PI: J. Wang, subcontract to NanoCVD, Co. through US-Army SBIR Phase II grant and Florida High Tech Corridor. Development of an uncooled infrared detectors consisting of a microscale antenna in conjunction with a nanoscale metal-insulator-metal tunnel diode (MIMTD). Successful development of uncooled nanoscale infrared high-speed sensors, in accordance with the proposed effort, will open up a variety of applications such as driver's night vision enhancement.



Selected Curriculum Activities

The WAMI faculty continues to advance the educational opportunities provided to undergraduate and graduate students in USF's Electrical Engineering Department. The Wireless Communications Laboratory, being developed by Dr. Arslan, was offered in three consecutive semesters (spring 2008, fall 2008 and spring 2009). This course has been a great success and a tremendous addition to the WAMI curriculum. A new course, Wireless Sensor Systems Design, will be offered for the first time in fall 2009. The sensors course is a collaborative effort between USF (Dr. Weller) and Northern Arizona University, the University of Vermont and the University of Hawaii. Funding to develop both courses was obtained through competitive Course, Curriculum and Laboratory Improvement grants from The National Science Foundation. In addition, a graduate-level course on Analog RFIC Design was offered in spring 2009 with the help of Mike Wyatt from ITT. The WAMI faculty will continue to offer the RFIC course in the years to come.





Course Syllabus

Course No. & Title: EEL 4936/EEL 6936 Wireless Communication Systems Lab

Term & Meeting Info: *Spring 2008*

Instructor Info:

Dr. Hüseyin Arslan;

E-mail Address: arslan@eng.usf.edu

Office: ENB 361

Phone: (813) 974-3940

Office Hours: Tuesday-Thursday, 1:45 – 2:45 p.m.

Catalog Description:

An extensive hands-on introduction to digital communications and wireless communication systems; involving testing, modeling, simulation, and measurements of the performance of digital communication systems at both sub -system and complete system levels. Not available on an S/U basis.

Semesters Offered: Spring Each Year

Prerequisites: Introduction to Communication Systems or equivalent.

Suggested Co-requisites: WAMI lab, DSP/FPGA labs, Personal & Mobile Communication, Advanced Topics on Wireless Communications.

Courses that require this course as a direct prerequisite: None

Level: *Senior level undergraduate and graduate*

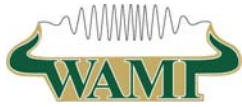
Credits: 3 **Class Duration:** 1 Hour and 45 minutes lecture + 4 hours lab

Text Info: *Instructor will provide the required documents.*

You are not granted permission to sell notes or tapes of class lectures.

Reference (supplemental reading): *Related reading material will be provided via web postings and handouts.*

Wireless Communications Lab syllabus



Center for Wireless and Microwave Information Systems

New Course Announcement !!

WIRELESS SENSOR NETWORK DESIGN A Multi-University Course

FALL 2009

This is a new senior-level elective being developed and taught collaboratively by multiple universities. The course will focus on system-level perspectives of real-world, wireless sensor networks by integrating topics from your courses in circuits, electromagnetics, signals/comm and computer engineering. Website: www.uvm.edu/~muse

Pre-requisite: Senior Standing in EE

Credit Hours: 3

At NAU register for EE 434 - contact: P. Flikkema

(co-requisite of EE 348 with waiver)

At USF register for EEL 4936 - contact: T. Weller

At UVM register for EE 295 - contact: J. Frolik

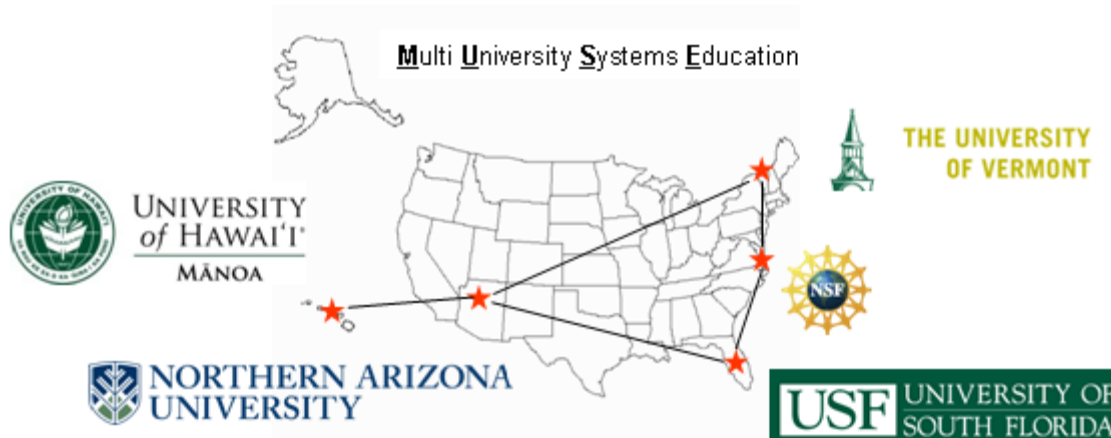
(pre-requisite EE 174)

❖ Course Topics

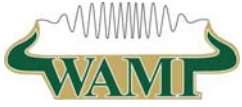
- Sensors/Transducers
- A/D Conversion
- Wireless Circuits
- Digital Communications
- Networks
- Embedded Computing

❖ Course Features

- Flexible Format: Online Lectures with In-Class Discussion
- Hands-on Projects
- Capstone Project Preparation
- Multi-University Collaboration
- Systems Thinking



Course Announcement for Wireless Sensor Systems Design



Center for Wireless and Microwave Information Systems

(Fall 2009)

Course name: “Cognitive and Software Defined Radio”

Instructor: Hüseyin Arslan

The course will also be offered through FEEDS

Course Description:

Today’s wireless services have come a long way since the rollout of the conventional voice-centric cellular systems. The demand for wireless access in voice and high data rate multimedia applications has been increasing. New generation wireless communication systems are aimed at accommodating this demand through better resource management and improved transmission technologies. The interest in increasing the *Spectrum Access* and improving the *Spectrum Efficiency* combined with both the introduction of Software Defined Radios and the realization of the idea that machine learning can be applied to radios has created new intriguing possibilities for wireless radio researchers. This course targets to discuss the cognitive radio, software defined radio, and adaptive radio concepts from several aspects. The scope will include the following:

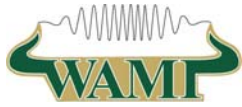
- Application of SDR in advanced communication systems
- Challenges and issues regarding the implementation of SDR
- Adaptive wireless communication systems
- Parameter estimation for adaptation of wireless communication systems (learning environment and other factors)
- SDR and cognitive radio architectures
- Spectrum efficiency and soft spectrum usage

Pre-requisites:

Some background on communications systems is needed to follow the course easily. EEL-6593 (Mobile and Personal Comm. Sys.) would perfect preparations for this course. However, students who have not taken this course should be able to follow the course with some communications and signal processing background. As always, if somebody has a *strong desire* to learn this course, all the above prerequisites do not make sense and can be waived.

Enrollment:

Since this is a new course, the enrollment will be limited to 15 students.



EEL6935: Analog RFIC Design

Spring 2009 Schedule: Lecture – Thursday, 5:15pm-8:00pm, ENG 201

| | | | |
|----------------------------|----------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------------|
| Instructor Name(s): | 1) Dr. Jing Wang | 2) Mr. Michael Wyatt | 3) Mr. Britt Kane |
| Telephone(s): | (813)-974-6011 | | |
| Facsimile(s): | (813)- 974-5250 | | |
| Email address(es): | jingw@eng.usf.edu | Mike.Wyatt@itt.com | brittinkane@comcast.net |

Office Hours: TBD. Students are also encouraged to ask questions in class.

Class Website: <http://ee.eng.usf.edu/gradcourses/AnalogRFIC2009>

The website is currently under development. The passwords will be given during the second 2nd lecture.

| Course: | | | | |
|-------------|--------|--------|--------------------|--------|
| Dept. Hours | Prefix | Number | Title | Credit |
| EGE | EEL | 6936 | Analog RFIC Design | 3 |

| | |
|----------------------|------------------------------------------------------------------------------------|
| Title: | "Analysis and Design of Analog Integrated Circuits", 4th Edition |
| Author(s): | Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer |
| Edition/Year: | Mar. 2001 |
| Publisher: | John Wiley & Sons, Inc. |
| ISBN #: | ISBN: 0-471-32168-0 |

Catalog Description:

This course presents the design theory, technology, and applications of silicon-based analog radio frequency integrated circuit (RFIC) technology. Lectures, homework and CAD projects develop understanding of the processing, design, and performance issues for CMOS and SiGe RFICs.

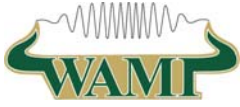
Goals/Objectives:

This course is intended to provide graduate students with a thorough understanding of modern RFIC design techniques. The first half of the class will focus on traditional basic analog design, while the second half of the class will target RF circuit implementations such as LNAs, Mixers, VCOs, and PAs. We will explore using both Bipolar and FET devices as circuit elements in RFIC circuits, and discuss typical Silicon technologies in use today such as SiGe, BiCMOS, and RF CMOS.

Course prerequisite: EEL 6935 RF & Microwave Circuits 2

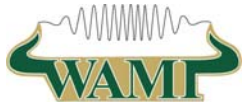
Course topics:

This is a graduate level course that discusses the design and analysis of RF and analog ICs. Course contents include an introduction to transceiver architectures; understanding of BJT and MOS device characteristics; description of noise and distortion in devices and circuits; biasing techniques including voltage references, current sources and biasing for low-noise applications; amplifier design techniques for low noise, variable gain, high output power and high dynamic range; integrated mixers and other frequency converters; rectifier circuits; and integrated oscillators and frequency synthesizers for generating fixed and variable frequencies. Relevant performance metrics and trade-offs are discussed. The optimization of designs for specific processes is also addressed, using examples of implementations in bipolar and CMOS technologies.



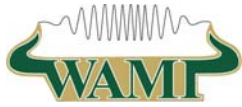
Professional Activities

- **Microwave and Wireless Technology Conference 2009** – The 10th annual conference was held April 20-21, 2009 in Sand Key, Florida. The WAMI Center faculty continues to play a key role in organizing this IEEE MTT-sponsored event. However, there is now a strong supporting cast of outside participants that are helping to make this conference a mainstay among the annual international microwave conferences. The conference attendance was ~150, with over 65 papers and 25 poster presentations.
- **WAMI 2009 Advisory Board Meeting** – The 12th meeting of the WAMI Center's External Advisory Board is scheduled for fall 2009. Information will be sent to board members and prospective guests in the latter part of the summer.
- **Establishment of the Florida Student Chapter for International Microelectronics And Packaging Society (IMAPS) at USF**– Dr. Wang was appointed as faculty advisor for IMPAS Florida Student Chapter in September, 2008. Currently, the president and vice-president of IMAPS society have been actively recruiting student members, and activities are planned for Fall 2009 semester.
- **2014 International Microwave Symposium** – Drs. Dunleavy and Weller are chair and co-chair, respectively, for the IEEE MTT Society's flagship conference that will be held in Tampa in 2014. While the event is still several years away, planning is already in progress!



Recent Publications and Presentations – 2008-09

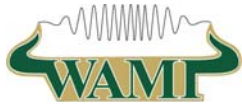
1. S. Melais and T. Weller, "A Quasi Yagi Antenna Backed by a Metal Reflector," IEEE Trans. AP, Vol. 56, No. 12, December 2008.
2. Venkataramanan Gurumurthy, Sathyaharish Jeedigunta, Sam Baylis, Ashok Kumar, and Thomas Weller, "Structural and Electrical Properties of Nanocrystalline Diamond based Barium Strontium Titanate Varactors" International Journal of Ferroelectrics, 15 December (2008).
3. E. Maxwell, T. Weller and E. Odu, "Design and Analysis of a Multi-Port Circuit for Shaping Sub-nanosecond Pulses," IEEE Trans. MTT, Vol. 56, No. 12, December 2008.
4. K. Stojak, S. Pal, S. Chandra, M.J. Miner, H. Srikanth, S. Skidmore, T. Weller, C. Morales, J. Wang and A. Horn, "Functional Nanocomposite Polymer Films with Uniform Magnetic Nanoparticle Dispersion," American Physical Society March Meeting, Pittsburgh, PA, March 2009.
5. B. Zivanovic, T. Weller and C. Costas, "Omni-Directional Array Using a Cylindrical Configuration of Slot-Coupled Microstrip Antennas," submitted to the European Microwave Conference, February 2009.
6. S. Aguilar and T. Weller, "Tunable Harmonic Re-Radiator for Sensing Applications," to be published in the proceedings of the 2009 IEEE International Microwave Symposium, June 2009.
7. S. Balachandran, D. Hoff, A. Kumar and T. Weller, "Nanocrystalline Diamond RF MEMS Capacitive Switch," accepted to the 2009 IEEE International Microwave Symposium, December 2008.
8. Q. Bonds, T. Weller, E. Maxwell, T. Ricard, and E. Odu, "A Total Power Radiometer (TPR) and Measurement Test Bed for Non-Contact Biomedical Sensing Applications," accepted to 2009 Wireless and Microwave Technology Conference, October 2009.
9. S. Melais and T. Weller, "A Multilayer Jerusalem Cross Frequency Selective Surface with Adequate Angular Stability at the 2.4GHz ISM Band," accepted to 2009 Wireless and Microwave Technology Conference, October 2009.
10. J. Cooper, B. Zivanovic, S. Melais, T. Weller, S. DiStasi, R. Ketcham and J. Frolik, "An Electrically Reconfigurable Reverberation Chamber for the Emulation of Severe Multipath Channels," accepted to 2009 Wireless and Microwave Technology Conference, October 2009.
11. C. Haden, P. Flikkema, T. Weller, J. Frolik, W. Verrei-Berenback and W. Shiroma, "ASSESSMENT OF A HYBRID, ON-LINE/IN-CLASS COURSE DEVELOPED AT MULTIPLE UNIVERSITIES," accepted to the 2009 ASEE Conference, October 2008.
12. M. J. Miner, S. Skidmore, T. Weller and H. Srikanth, "Superparamagnetic polymer nanocomposites for microwave applications" –abstract submitted to the 53rd Magnetism and Magnetic Materials (MMM) conference to be held in Austin, TX (Nov. 2008)
13. S. Balachandran, J. Kusterer, D. Maier, M. Dipalo, A. Kumar, T.M. Weller, E. Kohn, "High Power Nanocrystalline Diamond RF MEMS- A Combined Look at Mechanical and Microwave Properties", COMCAS 2008, Israel, May 2008. Invited paper.
14. B. Zivanovic, J. McKnight, T. Weller and C. Costas, "A Dual-Feed Series Microstrip Patch Array," accepted to 2008 IEEE International Antennas and Propagation Symposium, January 2008.
15. S. DiStasi, S. Melais, R. Ketcham, B. Zivanovic, J. Cooper, J. Frolik and T. Weller, "A compact, reconfigurable chamber for emulating severe multipath fading," IEEE Int. Symposium on Antennas and Propagation, San Diego, CA, July 5-12, 2008.
16. J. Frolik, P. Flikkema, W. Shiroma and T. Weller, "Work in Progress: MUSE – Multi-University Systems Education," 2008 Frontiers in Education Conference, January 2008.



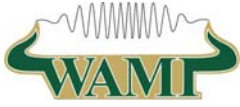
17. M. Miner, M. B. Morales, S. Skidmore, T. Weller and H. Srikanth, "Synthesis of surface functionalized nanoparticles and polymer nanocomposites" –APS March meeting, New Orleans LA (March 10 – 14, 2008)
18. T. Weller, H. Srikanth, J. Wang, C. Morales, J. Dewdney, S. Skidmore, S. Pal, S. Chandra, K. Stojak, "Microwave Characterization of Magnetic Polymer Nanocomposites using Transmission-line and Microwave Resonator Based Test Structures," 2009 CMMI Grantees Conference, Honolulu, HA, June 2009.
19. J. Frolik, P. Flikkema, W. Shiroma and T. Weller, "Work in Progress: MUSE - Multi-University Systems Education," 2008 Frontiers in Education Conference, Pittsburgh PA.
20. T. Weller, M. Miner, M. Morales, S. Skidmore, J. Gaas, H. Srikanth and J. Wang, "Functional Magnetic Polymer Nanocomposite Films for Tunable RF Device Applications," 2008 CMMI Grantees Conference, Knoxville, TN, January 2008.
22. H. Mahmoud, T. Yucek, and H. Arslan, "OFDM for Cognitive Radio: Merits and Challenges," to appear in IEEE Wireless Communications Magazine.
23. S. Yarkan, S. Guzelgoz, and H. Arslan, "Underground Mine Communications: A Survey," to appear in IEEE Communications Surveys and Tutorials.
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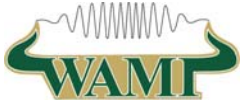
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