



**2013 IEEE  
Radio Frequency  
Integrated Circuits  
Symposium**

**Seattle, Washington, USA ■ 2–4 June 2013**

**Digest of Papers  
Editor: Timothy M. Hancock**

**Washington State Convention Center**

*Sponsored by*  
**IEEE Microwave Theory and Techniques Society  
IEEE Electron Devices Society  
and  
IEEE Solid-State Circuits Society**

# RFIC Symposium Activities (2–4 June 2013)

The RFIC Symposium will be held in Seattle, Washington at the Washington State Convention Center (WSCC) on 2–4 June 2013 in conjunction with the International Microwave Symposium. It opens Microwave Week 2013, the largest RF/Microwave meeting of the year. The RFIC Symposium brings focus to the technical accomplishments in RF Systems, circuit device, and packaging technologies for mobile phones, wireless communication systems, broadband access modems, radar systems and intelligent transport systems.

## Saturday, 1 June 2013

14:00–18:00      Registration — WSCC South Lobby

## Sunday, 2 June 2013

07:00–19:00      Registration — WSCC South Lobby  
07:00–08:00      Speakers' Breakfast — WSCC 6A  
07:00–08:00      Workshop Breakfast — WSCC 6<sup>th</sup> Floor, East & West Lobby Areas  
08:00–17:00      Workshops and Tutorials — WSCC  
12:00–13:30      Workshops Lunch — WSCC 6A  
18:00–19:30      RFIC Plenary — WSCC 6BC  
19:30–21:30      RFIC Reception — WSCC 6E

## Monday, 3 June 2013

07:00–19:00      Registration — WSCC South Lobby  
07:00–08:00      Speakers' Breakfast — WSCC 6A  
08:00–09:40      RMO1A, RMO1C, RMO1D — WSCC  
10:10–11:50      RMO2A, RMO2B, RMO2C, RMO2D — WSCC  
12:00–13:15      RFIC Panel — WSCC 6BC  
13:30–15:10      RMO3A, RMO3B, RMO3C — WSCC  
15:40–17:20      RMO4A, RMO4C, RMO4D — WSCC

## Tuesday, 4 June 2013

07:00–18:00      Registration — WSCC South Lobby  
07:00–08:00      Speakers' Breakfast — WSCC 6A  
08:00–09:40      RTU1B, RTU1C — WSCC  
10:10–11:50      RTU2A, RTU2B, RTU2C, RTU2D — WSCC  
12:00–13:30      RFIC Panel — WSCC 6A  
13:30–17:00      Interactive Forum — WSCC 6E

# Welcome Message from Chairpersons

Welcome to the 2013 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, which will take place in Seattle, WA, on 2–4 June 2013. Our Symposium is held in conjunction with the IEEE Microwave Theory and Technology Society's (MTT-S) International Microwave Symposium (IMS) and opens Microwave Week 2013, the largest worldwide RF/microwave meeting of the year, with three days focused exclusively on RFIC technology and innovation.

As in past years, the focus of the 2013 RFIC Symposium will be on emerging technologies and applications of Radio Frequency Integrated Circuits. This year, several forums will feature multiband reconfigurable, software-defined and cognitive radios, and the use of system-on-chips (SOCs) for realizing high data-rate, urban-environment, RF solutions for smart-phone, notepad, and notebook applications. The continued exploitation of frequencies above 60GHz in the realization of silicon millimeter wave circuits and systems will be presented throughout the conference. Lastly, the emergence of RF for biomedical applications and the reintroduction of wireline transceivers for high-speed I/O to our conference, reflect some of the exciting developments in the radio IC community. As in previous years, the latest advances in RFIC design from the device to the system level will be covered in various forums including workshops, panel sessions, and two exciting days of technical paper presentations.

The 2013 RFIC Symposium will open in grand style on Sunday, 2 June with a full lineup of 13 half-day and full-day workshops covering a wide array of topics with presentations from experts in their respective fields. This year's workshops will have a combination of tutorial and advanced presentations on some of the hottest topics in our community, including High-Efficiency Supply Modulated PAs, and Signal Generation at THz frequencies. The workshops will have a special full-day interactive Doherty tutorial workshop which will be offered with lab exercises where attendees can simulate (using ADS) designs and practice circuit concepts covered in the lecture, culminating in a complete high-power Doherty amplifier circuit design. One of the workshops, "Interference Robust Radio Receiver Techniques," focuses on the performance needs of modern integrated radios in an increasingly crowded spectrum. More advanced topics include SDR transmitters, the influence of MEMs on RF architectures, RF assisted Medicine, Self-Healing Circuits and Compensation, Near Field Communication, and VCO design in modern silicon processes. Other workshops will focus on the design of inductorless frontends, and how to push the RF performance limits in modern CMOS technologies.

The Plenary Session will be held on Sunday evening with keynote addresses given by two renowned industry leaders from the Pacific Northwest. They will share their insight on the direction of and challenges faced by the RFIC design community. The first speaker is Neville Ray, CTO of T-Mobile, who will discuss some of the exciting system developments from the cellular carrier perspective, with the talk, "*Wireless Spectrum Challenges & Opportunities: Maximizing Assets for Growth*." The second speaker is Barrie Gilbert, ADI Fellow, who will share his insight on the history of RF and wireless transceivers and present his vision of the future of RFIC design. The title of his talk will be "*Microwave Technology: The First Century*." During the plenary session, students with outstanding contributions to the conference will be recognized with the three best paper awards. Immediately following the Plenary Session, conference attendees can gather at the RFIC Reception, which provides a relaxing time for all to mingle with old friends and catch up on the latest news.

The RFIC technical sub-committees were further re-organized this year to align with the dynamic trends in industry and academia. Technical papers will be presented during oral sessions throughout Monday and Tuesday morning, followed by an interactive poster forum in the afternoon. This session features papers presented in poster format, giving the attendee a chance to speak directly with the authors regarding their work.

On both Monday and Tuesday, the conference will feature lunchtime panel sessions that traditionally draw lively debates among the panelists and stimulating interaction with the attendees. The Monday panel session is titled

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*“Cellular vs. WiFi: Future Convergence or an Utter Divergence”* and will debate how much future high speed data will be shared between WiFi and cellular networks and the implication on IC design. The Tuesday panel session titled *“Universities are from Venus, Industries are from Mars,”* explores the diverging aspects of University–Industry research, resource, and educational needs. A panel of leading academics and industrialists will explore the shared needs and differences between the university and corporate world, as well as discuss improved interactive models to better serve both industry and academics.

Seattle is one of the most beautiful cities in North America with countless activities both within the city, and the immediate surrounding area. The conference will be held at the Washington State Convention Center in downtown Seattle, just a few minutes’ walk from several local attractions. Conference attendees can enjoy a cup of coffee at the original Starbuck’s, watch flying fish at the world-renowned Pike Place Market, or take a ride to the top of the city’s iconic Space Needle. For the outdoor enthusiasts, several spectacular hiking trails can be found within an hour’s drive of the downtown area.

On behalf of the RFIC Steering Committee, we would like to extend to all of you a warm welcome to this year’s 2013 RFIC Symposium. We are looking forward to an exciting program and ask all of you to “come as you are,” this June in Seattle!

We look forward to seeing you!



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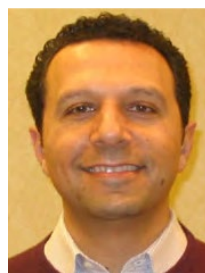
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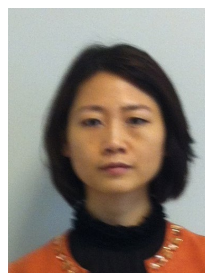
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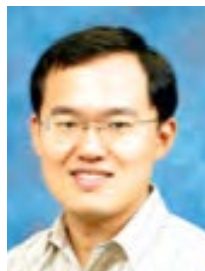
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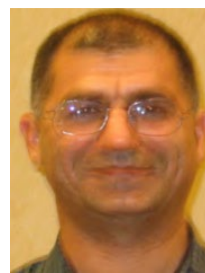
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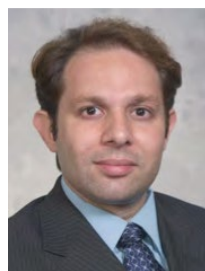
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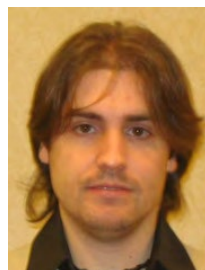
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Li-Wu Yang



Chen Yang



Patrick Yue



Gary Zhang



Albert Jerng

# RFIC 2013 Panel Sessions

Monday, 3 June 2013

12:00–13:15

WSCC 6BC

## Cellular vs. WiFi: Future Convergence or an Utter Divergence?

*Panel Organizer and Moderator:*

**Osama Shana'a** (Technical Director, MediaTek)

*Panelists:* **Eduardo Esteves** (Vice President, Qualcomm)

**Mike Hlavaty-LaPosa** (Director, AT&T)

**Alex Reznik** (Senior Director, Inter Digital)

**Pablo Tapia** (MTS, T-Mobile)

**Kambiz Shoarinejad** (Associate Technical Director, Broadcom)

**Pete Gelbman** (Former Director, Clearwire, now independent consultant)

**Abstract:** In recent years, there has been a tremendous need for high-data rate support by modern wireless communication systems due to end users excessive data usage and demand. On the cellular side, the downlink data rate throughput increased from <20Mbps in 3G HSPA to >100Mbps for 3.9G LTE Rel. 8 (and up to 1Gbps for LTE-A Rel. 10 & beyond). Meanwhile, WiFi data rate throughput also increased from <420Mbps for 802.11n to <4.9Gbps for 802.11ac wave 2. The boom of smart phones and social media services has pushed the need for higher data bandwidth, which subsequently has driven cellular networks to their limits. Cellular operators are now thinking of better ways to offload cellular networks from this extreme data stream demand by users. On one hand, femtocells seem promising because the spectrum can be re-used more frequently over a smaller geographical region, as small as a house, with easy access to the network backbone. On the other hand, WiFi networks are readily available in most homes and are easy to install and manage. Going into future 5G cellular with its higher projected data rates, will cellular networks become self-sufficient through proper micro/femto cell design and so meet the needs of end users to the point that WiFi would cease to exist? Or will cellular networks become limited to voice communication and selected data rate demands while high data rate communication is left to WiFi to handle in coordination with cellular networks?

This panel's distinguished experts from cellular/ WiFi chipset providers, cellular operators, and communication network/infrastructure manufacturers will present their perspectives on the topic above, especially the pros and cons of each approach, what the technical challenges are for future cellular generation network data traffic management, and how cellular and WiFi would ultimately converge (or otherwise diverge).

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# RFIC 2013 Panel Sessions

Tuesday, 4 June 2013

12:00–13:30

WSCC 6A

## Universities are from Venus, Industry is from Mars

*Panel Organizers and Moderators:*

**Hossein Hashemi** (University of Southern California)

**Ali Afshahi** (Broadcom)

*Panelists:* **Lawrence Larson** (Dean, Professor, Brown University)

**Ali Hajimiri** (Professor, Caltech)

**Sorin Voinigescu** (Professor, University of Toronto)

**David Su** (Vice President Engineering, Qualcomm Atheros)

**Curtis Ling** (Co-Founder and Chief Technical Officer, Maxlinear)

**Domine Leenaerts** (Senior Principal, NXP Semiconductors)

**Abstract:** Over the past two decades, the reduction in the number of government and industrial pure research labs and the increased demand from industry for highly-trained graduate students together have led to a large increase in the number and role of research universities and programs. For the most part, industry is unable or unwilling to support university research unless it is targeted for a specific, often near-term, application.

Faculty at universities are struggling to balance their main objective of conducting fundamental research with the need to train more graduate students who have specific skills that are of particular interest to industry. This panel will bring together participants from industry and academia to discuss and debate the role and objectives of university research, to define optimal university-industry interactions from both perspectives and to suggest ways to improve the symbiotic relationship between industry and universities. The panel session will also provide an opportunity for the audience to share their experiences and opinions and contribute to a lively discussion.

# WORKSHOPS AND SHORT COURSES

Workshops and Short courses are offered on Sunday, Monday and Friday of Microwave Week. Please see daily handout on Sunday, Monday, and Friday in the registration area and from volunteers throughout the meeting floors to confirm room location.

## SUNDAY WORKSHOPS – 2 JUNE 2013

**WSA (Half Day): Sunday 13:00–17:00**

### **State-of-the-Art RF and Low Noise CMOS Technologies: From Device to Circuit Level**

*Sponsors:* **MTT-6 Microwave and mm-Wave Integrated Circuits**

*Organizers:* **Jyh-Chyurn Guo**, *National Chiao-Tung University, Taiwan*  
**François Danneville**, *University of Lille, France*

**Abstract:** FinFETs appears as the most promising device technology for sub-20nm node, attributed to superior short channel integrity and analog performance. However, the potential impact on RF FoM and noise brings new challenges to RF/mm-wave circuits design on single-chip. Prior to sub-20nm, planar CMOS keeps the best choice for RF/mm-wave SoC. This workshop will present successful examples of low noise RF/mm-wave/THz circuits realized in planar CMOS technology, identify emerging challenges and solutions.

*Speakers:*

1. “The Impact of Layout Dependent Effects and Strain Engineering on High Frequency Performance and Low Frequency Noise in Nanoscale MOSFETs”, Jyh-Chyurn Guo, National Chiao Tung University, Taiwan
2. “Millimeter-Wave Ultra-Broadband CMOS LNAs Using Noise Reduction and Linearity Enhancement Techniques”, Tian-Wei Huang, National Taiwan University, Taiwan
3. “FinFET Technology for Analog/RF and mm-Wave Applications”, Morin Dehan, IMEC, Belgium
4. “Design Considerations for High-Frequency Low-Noise Integrated Circuits in Nanoscale (Bi)CMOS”, Payam Heydari, University of California at Irvine, USA

**WSB (Full Day): Sunday 08:00–17:00**

### **High Efficiency Supply-Modulated RF Power Amplifier**

*Sponsor:* **RFIC**

*Organizers:* **Donald Lie**, *Texas Tech University, USA*  
**Nick Cheng**, *Skyworks Solutions, USA*

**Abstract:** Broadband 3G/4G/WLAN wireless standards utilize inherent spectral-efficient modulation schemes with high peak-to-average power ratios (PAPR) and wide bandwidth, demanding highly linear RF PA design techniques that can offer excellent power-added efficiency (PAE) at both the maximum peak power and the back-off output power levels for mobile applications. As suggested by the recent market trends and the technical literature, the dynamic power-

*continues ...*

supply modulation schemes (e.g., the envelope-elimination-and-restoration (EER) and the envelope-tracking (ET)) are among the most effective methods for RF PA efficiency enhancement at both peak and back-off output power modes.

Eight world experts from both industry and academia will present the latest design techniques, research, and market trends of high efficiency supply-modulated RF power amplifiers in this workshop. Topics such as “the linearity and efficiency trade-offs, design techniques for integrated ultra-high efficiency wideband supply modulators for RFIC applications”, “Co-design of power amplifier and dynamic power supplies for radar and communications transmitters”, etc., will be presented. In addition, the switching noise concerns for the envelope-tracking power amplifier (ET-PA), circuits/system design techniques and bandwidth requirements will be discussed in this workshop to address the practical issues in realizing successful supply-modulated high-efficiency RF PA systems.

*Speakers:*

1. “Design Techniques for Integrated Ultra-High Efficiency Wideband Supply Modulators for RFIC Applications”, **Larry Larson**, *Brown University, USA*
2. “High Efficiency Supply-Modulated RF Power Amplifier for Handset Applications”, **Bumman Kim**, *POSTECH, Korea*
3. “Design Considerations for Wideband Envelope Tracking Power Amplifiers”, **David Ripley**, *Skyworks Solutions, USA*
4. “Power Amplifier Design Techniques for Envelope Tracking”, **James Retz**, *RF Micro Devices, USA*
5. “Design of Monolithic Silicon-Based Envelope-Tracking Power Amplifiers for Broadband Wireless Applications”, **Donald Lie**, *Texas Tech University, USA*
6. “Co-Design of Power Amplifier and Dynamic Power Supplies for Radar and Communications Transmitters”, **Zoya Popovic**, *University of Colorado at Boulder, USA*
7. “Digital Signal Processing for Envelope Tracking Systems”, **Paul Draxler**, *Qualcomm, USA*
8. “Envelope Tracking and Energy Recovery Concepts for RF Switch-Mode Power Amplifiers”, **Thomas Johnson**, *University of British Columbia, Canada*

### **WSC (Half Day): Sunday 08:00–12:15**

#### **Interference Robust Radio Receiver Techniques**

*Sponsor:* **RFIC**

*Organizers:* **Eric Klumperink**, *University of Twente, The Netherlands*  
**Didier Belot**, *STMicroelectronics, France*

**Abstract:** The radio spectrum becomes more and more crowded, and radio devices become interference limited. As there is a demand for multi-mode flexible radio devices, traditional dedicated narrowband filtering is no longer enough and new techniques are wanted for interference rejection.

This workshop will review different approaches to address this challenge, e.g. interference cancellation techniques, linearization, spatial interference rejection via multiple antennas, flexibly tunable N-path filtering.

*Speakers:*

1. “Linearity Enhancement Techniques in Radio Receiver Front-Ends”, **Ranjit Gharpurey**, *University of Texas at Austin, USA*

2. “Translational Loop Filtering for Interferer Rejection at the LNA Input”, **Andreas Kaiser**, *IEMN, France*
3. “Mixer-First Receivers with High Out-of-Band Linearity”, **Caroline Andrews**, *Passif Semiconductor, USA*
4. “Blocker Tolerant N-Path Filter Techniques”, **Ahmad Mirzaei**, *Broadcom, USA*
5. “Spatial Interference Rejection in Multi-Antenna CMOS Radio Receivers”, **Michiel Soer**, *University of Twente, The Netherlands*

**WSD (Full Day): Sunday 08:00–17:00**

## **Pushing the Ultimate Performance Limits of RF CMOS**

*Sponsor:*     **RFIC**

*Organizers:* **Gernot Hueber**, *NXP Semiconductors, Austria*  
**R. Bogdan Staszewski**, *TU Delft, The Netherlands*

**Abstract:** Advances in CMOS fabrication technology have enabled the use of CMOS technology in today’s RF transceivers for wireless communications. Multi-band and multi-mode radios covering the diversity of communication standards from cellular (2G, GSM, 3G UMTS, to 4G LTE and LTE-advanced) through Bluetooth and WLAN to GPS, etc., impart unique challenges on the RF-transceiver design due to limitations in terms of reconfigurable RF components that meet the demanding RF performance criteria at costs that are attractive for mass market applications.

The focus of this workshop will be to discuss the performance limits of key RF building blocks in CMOS such as oscillators with minimal phase noise, transmitters with maximum modulation rate, and best linearity for the RX.

Approaches include novel architectures, highly configurable analog circuitry, digitally assisted and enhanced analog/RF modules and the integration of digital signal processing into the traditionally purely analog front-end.

*Speakers:*

1. “System Requirements Pushing the Limits of RF CMOS”, **Walid Y. Ali-Ahmad**, *MediaTek, Singapore*
2. “Pushing the Spurious Free Dynamic Range of CMOS RF Front-Ends”, **Eric Klumperink**, *University of Twente, The Netherlands*
3. “Pushing the Power in Digital Transmitters”, **Jan Craninckx**, *IMEC, Belgium*
4. “Limitations in CMOS Polar PAs”, **Jeff Walling**, *University of Utah, USA*
5. “Pushing the Limits of Frequency Synthesizers to Ultra-Low Phase Noise, Spur-Free and mm-Wave”, **R. Bogdan Staszewski**, *TU Delft, The Netherlands*
6. “Design of Low-Power RF Circuits in Deep-Submicron CMOS”, **Christian Enz**, *CSEM, Switzerland*
7. “Filtering Aspects of an All-Digital Transceiver for Mobile Applications”, **Frank Op ‘t Eynde**, *Audax Technologies, Belgium*
8. “Digital RF Signal Generation for Ultimate Transmitters”, **Antoine Frappé**, *IEMN, France*

*continues ...*

**WSE (Half Day): Sunday 13:00–17:00**

**Inductor-Less and Noise/Distortion Cancellation and Mitigation Techniques in RF Circuit Design**

*Sponsor:* **RFIC**

*Organizers:* **Danilo Manstretta**, *University of Pavia, Italy*  
**Osama Shana'a**, *MediaTek, USA*

**Abstract:** In recent years inductor-less and noise/distortion cancelling design techniques have emerged as key innovations in RF circuit design to improve performance, lower power dissipation, reduce circuit area and save cost. This workshop attempts to provide an overview on the following topics:

1. History and evolution of thermal noise canceling in LNAs and receivers
2. Wideband LNA linearization techniques
3. Blocker and Distortion Cancellation Techniques for 3G/4G Full-duplex Systems
4. PLL noise and spur reduction based on sub-sampling phase detection
5. Nonlinearity mitigation in digital PLLs

*Speakers:*

1. “Thermal Noise Canceling in LNAs and Receivers: history and developments”, **Eric Klumperink**, *University of Twente, The Netherlands*
2. “Linearization Techniques for CMOS Low Noise Amplifiers: A Tutorial”, **Heng Zhang**, *Texas A&M University, USA*
3. “Blocker and Distortion Cancellation Techniques for 3G/4G Full-Duplex Systems”, **Mohyee Mikhemar**, *Broadcom, USA*
4. “PLL Noise and Spur Reduction Techniques Based on Sub-Sampling Phase Detection”, **Xiang Gao**, *Marvell Semiconductor, USA*
5. “Non-Linearity Mitigation in Digital PLLs for High-Performance Transmitters”, **Salvatore Levantino**, *Politecnico di Milano, Italy*

**WSF (Half Day): Sunday 13:00–17:00**

**RF Assisted Medicine**

*Sponsor:* **RFIC**

*Organizers:* **Hua Wang**, *Georgia Institute of Technology, USA*  
**Sayfe Kiaei**, *Arizona State University, USA*

**Abstract:** With the rapid growth of novel integrated sensors, low-power circuits/systems, and energy-efficient wireless communications, radio-frequency (RF) technology has become one of the major enabling factors for future personalized healthcare. This workshop, entitled “RF Assisted Medicine”, is designated to showcase the state-of-the-art technologies in this fast evolving area. We will cover two major and highly correlated topics in this program – RF medically implanted sensors and wireless body area networks (WBAN). The first topic focuses on providing high-performance in vivo sensing

*continues ...*



and actuation as well as information/power transmission between internal and external devices on the human body, while the second topic aims at establishing efficient wireless communications among multiple miniaturized body sensor units (BSU) and a single body central unit (BCU). The synergistic integration of the two technologies has the potential to enable a plethora of diagnostic and therapeutic applications in future medical care. In order to provide a high-quality education opportunity for the attendees while maintaining a coherent theme, we propose to organize the workshop with four related sessions as follows.

1. Overview of RF technologies in assisted medicine. This session will serve as a high-level review on the field and emphasis on the various applications which utilize RFIC to assist the medicine and a healthy living of the users. Topics including top-level market size/trend, current medical applications, technologies, and system architectures will be covered. This talk therefore serves as an introduction for the workshop and demonstrates the high-level pictures of this rapidly growing field.
2. Power and Data Transmission to Implantable Microelectronic Devices. This talk will focus on how to establish the wireless link into/from inside the body (IMD). Fundamentals of efficient power and wireless data transmission into/from the body will be presented, which is a perfect example of how RF technologies are used in assisted medical applications. This wireless power and data transmission technology is also the core part of many implantable medical electronics. Moreover, design optimization procedures, using two-, three-, and four-coil resonant systems, will be discussed to achieve the highest possible power transmission efficiency. Some of the latest techniques will also be reviewed to establish wideband bidirectional communication links across the skin.
3. WBAN: Medical Applications and Challenges. In parallel to the wireless links across the skin, this session will present another aspect of how to establish energy-efficiency wireless link outside of the body based on Wireless Body Area Networks (WBANs), which is another example of how RF technologies will assist medical applications. This talk will first provide an overview of WBANs, including emerging medical applications and recent standards activity. Challenges and opportunities for WBANs systems will be discussed, including areas where current technology falls short and innovations are required in order to meet targets for reliability, security, and sensor lifetime.
4. Wireless Real-Time Monitoring of Brain Neurochemistry. This presentation will focus on a key example application of RF assisted medicine which performs chemical recording for neural engineering. The presented wireless real-time monitoring technology achieves high-Mbps data transmission over meter-range distances. The talk will first introduce neural engineering applications and describe the fundamentals of brain interfacing. Then it will showcase one example of engineered devices for real-time, concurrent sensing of neurochemical signals and electrical action potentials in mouse brains. Various design/implementation challenges due to high-site-density wireless monitoring will be highlighted, and emerging wireless communication technologies to potentially address these challenges will be discussed.

*Speakers:*

1. “Wireless Medical Systems: Concepts and Applications”, **Tim Denison**, *Brown University, USA*
2. “Transcutaneous Power and Data Transmission to Implantable Microelectronic Devices”, **Maysam Ghovanloo**, *Georgia Institute of Technology, USA*
3. “WBAN: Medical Applications and Challenges”, **David Wentzloff**, *University of Michigan, USA*
4. “Wireless Real-Time Monitoring of Brain Neurochemistry”, **Pedram Mohseni**, *Case Western Reserve University, USA*

**WSG (Full Day): Sunday 08:00–17:00**  
**Radio Frequency Systems for Indoor Localization**

*Sponsor:*     **RFIC**

*Organizers:* **Aly E. Fathy**, *University of Tennessee, USA*  
                  **Martin Vossiek**, *University of Erlangen-Nuremberg, Germany*

**Abstract:** Radio frequency systems for indoor localization pose many challenges in RFIC design, since they combine broadband radar, communication and high precision synchronization techniques. In addition, powerful real time signal processing capabilities are needed for signal evaluation, multipath mitigation and sensor fusion. During the last years tremendous development efforts could be noticed in the area of indoor local positioning system. The workshop will cover RFIC design as well as system design aspects and will show recent applications of Radio Frequency Systems for Indoor Localization.

*Speakers:*

1. “Impulse-Radio UWB Systems for In-Body Localization and Vital Sign Monitoring”, **Hermann Schumacher**, *Ulm University, Germany*
2. “24GHz CMOS Transceiver and Wireless Sensor Network for Indoor Localization – Part A Transceiver Design”, **Amin Hamidian**, *Berlin University of Technology, Germany*
3. “24GHz CMOS Transceiver and Wireless Sensor Network for Indoor Localization – Part B Sensor Network and Measurement Results”, **Randolf Ebelt**, *University of Erlangen-Nuremberg, Germany*
4. “Ultra Wide Band Indoor Precise Localization Systems”, **Aly E Fathy**, *University of Tennessee, USA*
5. “CMOS micro-radars for noncontact detection of human vital signs”, **Jenshan Lin**, *University of Florida, USA*
6. “UWB Real Time Locating Systems”, **Tim Harrington**, *Zebra Technologies, USA*
7. “Impulse Radio for Accurate Indoor Localization”, **Xiaoyan Wang**, *Holst Centre, The Netherlands*
8. “Ultra Wideband Ranging Radio Transceiver for Indoor Localization”, **Brandon Dewberry**, *Time Domain, USA*
9. “Localization of Standard Compliant Passive RFID Transponders”, **Robert Miesen**, *University of Erlangen-Nuremberg, Germany*

**WSH (Full Day): Sunday 08:00–17:00**  
**Self-Healing Mixed-Signal Circuitry: Built-In Calibration and Compensation Techniques**

*Sponsor:*     **RFIC**

*Organizers:* **Oren Eliezer**, *Xtendwave, USA*  
                  **Ali Afsahi**, *Broadcom, USA*  
                  **Sudipto Chakraborty**, *Texas Instruments, USA*

**Abstract:** Current day system-on-chip (SoC) RFICs are expected to reliably deliver high performance at low cost, while design cycles of these highly complex products are short and limited in design resources.

Furthermore, a typical SoC in a consumer-market device, such as a cellphone transceiver, is characterized by substantial digital content, including digital processing power and memory, for which high production yield and low testing costs are expected.

Hence, the analog/mixed-signal circuitry in these products, while typically being designed under tight schedules and with limited resources, must meet demanding performance specifications across all corners of the fabrication process, while also allowing for low-cost testing and high production yield. This combination of requirements can be met only if the analog/mixed-signal circuitry accommodates built-in calibration and compensation mechanisms, allowing it to “self-heal” in scenarios where it may fail due to variations in fabrication process, operating conditions, or aging.

The implementation of built-in calibration/compensation involves the capabilities of built-in measurements, as well as signal processing and parameter adjustment (current, voltage, timing, capacitance, etc.), which may be of high complexity. However, such resources can be made affordably available on the SoC, making this design approach an increasingly popular one in the industry.

The workshop includes a total of 8 talks, provided by industry experts and academia researchers, covering the fundamentals of the “self-healing” design approach, many successful implementation examples demonstrating the approach within various industry leaders, and theoretical analysis related modeling and reliability.

The workshop’s comprehensive coverage of the topic and its interactive nature, will allow attendees to ask questions and share ideas about all aspects of this topic, and to ultimately become better equipped in making design and design-management decisions in future RFIC SoCs.

*Speakers:*

1. “Adaptive Digital Pre-Distortion for ET Transmitters”, **Paul Draxler**, *Qualcomm, USA*
2. “Loop-Back Design and Applications as the Foundation for BIST and BISC”, **Christopher Hull**, *Intel, USA*
3. “Design of Self-Calibration Solutions in Low Power RF Transceivers”, **Sudipto Chakraborty**, *Texas Instruments, USA*
4. “Reliability Analysis, Built-In Monitoring, and Modeling of Aging and Failures in RF/Analog Circuits”, **Sule Ozev**, *Arizona State University, USA*
5. “Modeling and Self-Healing of Analog/RF Circuits: A Statistical Approach”, **Xin Li**, *Carnegie Mellon University, USA*
6. “Calibration and Compensation Techniques for Wireless Transceivers”, **Theodoros Georgantas**, *Broadcom, USA*
7. “Self-Healing Mixed-Signal Circuitry: Built-in Calibration and Compensation Techniques”, **Jose Silva-Martinez**, *Texas A&M University, USA*
8. “Built-In Digital Calibration/Compensation in Low Cost RF SoCs”, **Oren Eliezer**, *Xtendwave, USA*

## **WSI (Half Day): Sunday 13:00–17:00**

### **Near Field Communication (NFC), Design Techniques and Challenges**

*Sponsor:*     **RFIC**

*Organizers:* **Magnus Wiklund**, *Qualcomm Atheros, USA*  
**Gernot Hueber**, *NXP Semiconductors, Austria*

**Abstract:** Short-Range Near-Field Communications (NFC) and wireless charging has become a technology on the way to deployment in the high volume market of mobile devices (smartphones, tablets). NFC is used in various applications such as gaming, ticketing, and mobile payments (Google Wallet). Wireless charging is also becoming popular in the quest to remove cables from mobile devices. The interest of the RFIC community is to explore technological challenges and boundaries of what our modern integrated circuit processes have to offer, which architecture and how to design on circuit level. It turns out that RFIC development of NFC circuits is a highly advanced topic. This workshop is to address NFC-forum compliant devices from both, system and circuit design level including testing as well as wireless charging. The format of the workshop is educational. Following up on last years “tradition” we intend to end the workshop with a “hands-on” demo of NFC technology.

*Speakers:*

1. “Near Field Assisted UWB: TransferJet”, **Ichiro Seto**, *Toshiba Corporation, Japan*
2. “WiPower”, **Chuck Wheatley**, *Qualcomm, USA*
3. “NFC Fundamentals from a PA Point of View”, **Rainer Gaethke**, *Qualcomm Atheros, USA*
4. “Design Techniques for Low Power, Multi-Standard NFC Solutions”, **Michael Gebhart**, *NXP Semiconductors, Austria*

## **WSJ (Half Day): Sunday 08:00–12:00**

### **MEMS in Our World: RF and Analog/Mixed-Signal Circuits and Architectures**

*Sponsor:*     **RFIC**

*Organizers:* **Fred S. Lee**, *Fairchild Semiconductor, USA*  
**Derek K. Shaeffer**, *InvenSense, USA*

**Abstract:** This workshop covers a variety of MEMS-based systems that have found widespread adoption and growth in our world, as well as nascent MEMS-based technologies that aim to change our lives. There is no doubt that the success of MEMS-based systems rests in the great strides that have been made in MEMs fabrication. However, this workshop will focus on the lesser-known reason for success: empowering collaborations between MEMS and RF/analog/mixed-signal design.

*Speakers:*

1. “MEMS Timing for the Mobile Era”, **Haechang Lee**, *SiTime, USA*
2. “Integrated Micromechanical Circuits for RF Front-Ends”, **Clark Nguyen**, *University of California at Berkeley, USA*

*continues ...*

3. “MEMS Inertial Sensors for RF Designers”, **Derek K. Shaeffer**, *InvenSense, USA*
4. “Optimizing Radio Architectures with MEMS Elements to Enable Reconfigurable Front-Ends and Cognitive/ Software-Defined Radio”, **Gabriel M. Rebeiz**, *University of California at San Diego, USA*
5. “MEMS-Based Tuning for RF Front-Ends”, **Arthur Morris**, *WiSpry, USA*

**WSK (Full Day): Sunday 08:00–17:00**

## **Tutorial on Doherty Power Amplifier Circuits and Design Methodologies**

*Sponsor:*     **RFIC**

*Organizers:* **Damon Holmes**, *Freescale Semiconductor, USA*  
**Jean-Christophe Nanan**, *Freescale Semiconductor, France*  
**Mario Bokatius**, *Freescale Semiconductor, China*  
**Joe Staudinger**, *Freescale Semiconductor, USA*

**Abstract:** The Doherty method has become the power amplifier of choice for cellular infrastructure applications due to its high efficiency at backoff power levels and recent advancements in digital pre-distortion (DPD) techniques that mitigate its non-linear behavior. In this course, the Doherty power amplifier technique will be discussed and analyzed in detail with emphasis on attributes and implementation for high power infrastructure applications. After review of transmitter requirements and driving market forces within the cellular infrastructure market, the material focuses on some of the underlying principles and key fundamentals of the Doherty amplifier. Idealized analysis of symmetric, asymmetric and N-way architectures is given that shows the governing design equations for high efficiency Doherty amplifiers and reveals its advantages beyond cellular infrastructure applications. From this point onward, attention is focused on certain key physical impairments associated with high power Doherty amplifiers which must be considered in practice. Chief among these are device finite output impedance and degradations resulting from the Peaking sub-amplifier, frequency dispersion, and carrier and peaking sub-amplifier gain and phase inequalities. Each concept is introduced one by one to give the attendee insight into their limitations, and some techniques to compensate their deleterious effects are presented as well. Considerable emphasis is placed throughout the material to identify key challenges faced by those practitioners in this field. Those “real-world” challenges are easily and conveniently demonstrated through the use of large signal device models and loadpull characterization. It is shown how performance can be maximized through input signal splitter, output summing network optimization, and implementing proper phase compensation.

The afternoon portion of the course is a hands-on laboratory exercise where a 500 watt Doherty amplifier is designed and simulated using a CAD tool. The student will import loadpull measurement data into the CAD tool for comparison with device model data. Doherty input and output matching networks will be synthesized by the student with special attention given to tradeoffs between gain, efficiency, power capability and AM/PM distortion. Impairments outlined in the classroom portion of the course will be mitigated by the student to maximize Doherty performance. Final Doherty evaluation will be accomplished using non-linear device models in harmonic balance and circuit envelope simulations. Students are encouraged to take the resulting Doherty CAD project home with them upon completion of the course.

*Outline:*

1. Market forces, requirements, trends and infrastructure landscape
2. Review of power amplifier concepts
3. Doherty amplifier load modulation

*continues ...*



4. High power devices and physical impairments
5. High power Doherty design and realization
6. Simulation laboratory

*Instructors:*

1. Damon Holmes, Freescale Semiconductor, Tempe, AZ. Damon has extensive experience in the area of RF hardware development, especially Doherty amplifiers, and in optimizing power amplifiers for pre-distortion systems targeting cellular infrastructure.
2. Jean-Christophe Nanan, Freescale Semiconductor, Toulouse, France. Jean-Christophe is a power amplifier architect at Freescale with extensive experience in systems and circuit design.
3. Mario Bokatius, Freescale Semiconductor, Shanghai, China. Mario has over 15 years of experience in designing small signal and high power amplifiers for a variety of wireless applications.
4. Joe Staudinger, Freescale Semiconductor, Tempe, AZ. Joe has 30+ years of experience in the areas of advanced power amplifier systems, transmitter architectures, and large signal device/system modeling for wireless communication systems.

**WSL (Half Day): Sunday 08:00–12:00**

**RFIC VCO Design**

*Sponsor:*     **RFIC**

*Organizers:* **Marc Tiebout**, *Infineon Technologies, Austria*  
**Domine Leenaerts**, *NXP Semiconductors, The Netherlands*

**Abstract:** VCO performance is critical for numerous RFIC applications including Receivers, Transmitters, Imagers, Radar systems and many more. This educational workshop will refresh the fundamentals of VCO design including an overview of common phase noise theories. State-of-the-art RFIC VCO designs in integrated CMOS and Bipolar/BiCMOS technologies will be covered in detail, not only including a focus on mobile operation, but also on wideband ultra low noise base station requirements. Further contributions will focus on the design for mm-wave operation and ultra low power. In addition, the topic of accurately measuring phase noise will complete the coverage of the VCO design. The topics covered in the workshop include:

1. VCO basics and specifications
2. Phase Noise Theories
3. Topology comparison of cross-coupled, Colpitts, ring-type, etc.
4. Mobile phone VCO design
5. Ultra low phase noise for base stations
6. Harmonic VCO design
7. mm-wave design
8. Ultra low power design
9. Ultra low phase noise design
10. Octave-band tuning
11. Accurate measurements

*continues ...*

*Speakers:*

1. “VCO Basics and Harmonic VCO Design in CMOS”, **Andrea Bevilacqua**<sup>1</sup>, **Pietro Andreani**<sup>2</sup>, <sup>1</sup>*University of Padova, Italy*, <sup>2</sup>*Lund University, Sweden*
2. “VCO-Based Frequency Synthesis in SiGe for mmWave Radar Systems”, **Nils Pohl**, *Fraunhofer FHR, Germany*
3. “The Design of Ultra Low Power Oscillators”, **Christian Enz**, *CSEM/EPFL, Switzerland*
4. “Ultra Low Noise Octave Band VCO’s for Base-Stations”, **Ulrich Rohde**, *Synergy Microwave, USA*
5. “VCO Design Workshop Accurate Phase Noise Measurements”, **Salam Marougi**, *Agilent Technologies, USA*

**WSM (Half Day): Sunday 13:00–17:00**

**Software Defined Radio Frequency Transmitters**

*Sponsor:* **RFIC**

*Organizers:* **Sanjay Raman**, *Virginia Tech and DARPA, USA*  
**Walid Y. Ali-Ahmad**, *MediaTek, Singapore*

**Abstract:** Flexibility and reconfigurability are the new keywords in RF design; many applications require transceivers operating in different modes and bands to fulfill market requirements. Recent research has shown two very different trends. Classical analog-inspired architectures focus on performance numbers that are on par with dedicated radios, while employing circuits and techniques that offer some level of programmability at low cost. Digital-intensive approaches offer flexibility almost for free, and scale well to new technology nodes, but still face RF performance challenges.

This workshop covers the latest research developments in the area of software defined radio transmitters. With the advancement in semiconductor technologies, highly-programmable transmitter architectures leveraging digital and mixed-signal processing have become more prevalent. Some examples include Digital Polar Transmitters (DPT), Radio-Frequency Digital to Analog Converters (RF DAC), high-power digital waveform generation and synthesis (PowerDAC), and switched-capacitor based transmitters.

The invited speakers are prominent researchers in the area of SDR transceiver circuits, and represent both academia and industry at leading organizations in the US and Europe.

*Speakers:*

1. “Overview of SDR Transmitters, Analog vs. Digital Architectures”, **Jan Craninckx**<sup>1</sup>, **Sayfe Kiaei**<sup>2</sup>, <sup>1</sup>*IMEC, Belgium*, <sup>2</sup>*Arizona State University, USA*
2. “Byting the Digit: RF and mm-Wave ‘Digital’ Transmitters”, **Ali Niknejad**, *University of California at Berkeley, USA*
3. “From Software Radio-Frequency Transmitters to Highly-Reconfigurable mm-Wave Transmitters”, **R. Bogdan Staszewski**, *TU Delft, The Netherlands*
4. “Polyphase Upconversion Techniques”, **Bram Nauta**, *University of Twente, The Netherlands*
5. “High-Power Efficient RF Digital-to-Analog Converter (HiPERDAC)”, **Gerhard Solner**, *Raytheon, USA*

**WSN (Full Day): Sunday 08:00–17:00**

## **Signal Generation, Amplification, Detection and System Implementation at THz Frequencies**

*Sponsors:* **RFIC, MTT-4 Terahertz Technology and Applications**

*Organizers:* **Georg Boeck**, *Berlin Institute of Technology, Germany*  
**Ullrich Pfeiffer**, *University of Wuppertal, Germany*

**Abstract:** Recently integrated circuits in silicon and III/V-technologies have been pushed towards terahertz frequencies which present both challenges and opportunities for emerging applications and circuits. This workshop presents recent attempts to operate circuits close to and beyond their transistor cut-off frequencies.

Silicon process technologies have reached  $f_{\max}$  as high as 0.5 THz, which enables circuits to operate fundamentally up to about 250 GHz with reasonable RF circuit performance. Cut off frequencies of III/V transistors are currently touching the 1 THz border. Beyond  $f_{\max}$ , where transistors do not provide power gain, circuits may be operated sub-harmonically to extend further the operation region. Despite their increased receiver NF, such circuits prove to be useful for emerging applications. At terahertz frequencies, on-chip antennas may be implemented with reasonably high efficiencies and very small area, thus eliminating the need for additional external components such as expensive waveguides or horn antennas. Topics covered during the workshop include:

1. THz applications
2. Technology overview
3. Signal generation and detection at THz frequencies
4. III/V, SiGe, CMOS and Schottky diode circuit design at THz frequencies
5. Transceiver and integration technologies, integrated antennas, packaging
6. Circuit characterization methodologies up to and beyond 1 THz
7. Emerging terahertz applications and systems

*Speakers:*

1. “THz Technologies: Transistors, ICs, Systems”, **Mark Rodwell**, *University of California at Santa Barbara, USA*
2. “THz Transceiver Circuits in InP-DHBT Technology”, **Herbert Zirath**, *Chalmers University of Technology, Sweden*
3. “mHEMT-Based MMIC Frontends for THz Radar and Communication”, **Ingmar Kallfass**, *University of Stuttgart, Germany*
4. “Schottky and MOS Diodes in CMOS for Sub-Millimeter Wave Signal Generation and Detection”, **Kenneth K. O.**, *University of Texas at Dallas, USA*
5. “Ideas for THz Power Generation and Radiation in Silicon”, **Ali Hajimiri**, *Caltech, USA*
6. “Compact 680GHz Wave Imaging Radar Systems”, **Adrian Tang**, *NASA Jet Propulsion Laboratory, USA*
7. “THz in CMOS: Challenges and Opportunities”, **Ehsan Afshari**, *Cornell University, USA*
8. “THz Sources and Imaging Systems Based on CMOS and SiGe Arrays with High-Efficiency On-Chip Antennas”, **Gabriel M. Rebeiz**, *University of California at San Diego, USA*
9. “Towards Single-Chip Silicon Transceivers for Sensors and Radios Above 200GHz”, **Sorin Voinigescu**, *University of Toronto, Canada*

*continues ...*

10. “Silicon RF Front-Ends for Active THz Imaging Systems”, **Ullrich Pfeiffer**, *University of Wuppertal, Germany*

**WSO (Full Day): Sunday 08:00–17:00**

**Holistic Approach to Transceiver Architectures and Technologies to Femto/Pico Cell Based Communication Systems**

*Sponsor:* **MTT-20 Wireless Communication**

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## **SUNDAY SHORT COURSES – 2 JUNE 2013**

**SC-1: Sunday 08:00–17:00**

**Compact Modeling and Design of RF Switches**

*Sponsor:* **MTT-1 Computer Aided Design**

**SC-2: Sunday 08:00–17:00**

**Demystifying Device Characterization – An Interactive Course for Transistor Characterization Through Behavioral and Compact Modeling and Load Pull**

*Sponsor:* **MTT-11 Microwave Measurements**

**SC-3: Sunday 08:00–17:00**

**Spectrum Policy Issues for Innovative RF Engineers**

*Sponsor:* **MTT-20 Wireless Communications**

**SC-4: Sunday 08:00–17:00**

**Co-Design of On-Chip Antennas and RF Circuits for System-on-Chip Applications**

*Sponsors:* **RFIC, MTT-6 Microwave and mm-Wave Integrated Circuits**

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## **MONDAY WORKSHOPS – 3 JUNE 2013**

**WMA (Full Day): Monday 08:00–17:00**

**Advancements in InAlN/GaN Device and Microwave/MMW Circuit Technology**

*Sponsors:* **MTT-6 Microwave and mm-Wave Integrated Circuits**

*continues ...*

**WMB (Half Day): Monday 08:00–12:00**

**How to Start and Grow Your High Tech Company**

*Sponsor:* **MTT-16 Microwave Systems**

**WMC (Full Day): Monday 08:00–17:00**

**The Importance of Low-Frequency Measurements on High-Frequency Characterization**

*Sponsors:* **ARFTG, MTT-11 Microwave Measurements**

**WMD (Full Day): Monday 08:00–17:00**

**Technologies for THz Integrated Systems**

*Sponsors:* **RFIC, MTT-4 Terahertz Technology and Applications**

*Organizers:* **Mona Hella**, *Rensselaer Polytechnic Institute, USA*  
**Arun Natarajan**, *Oregon State University, USA*

**Abstract:** Sub-mm-wave and terahertz frequencies have long been attractive for imaging and communication applications. However, technological limitations have impeded the development of commercial systems at such frequencies. THz systems integration is critical for lowering the cost and enabling mass-markets. Several technologies have been proposed and are currently being investigated to address this need. In this workshop, speakers from academia and industry will address the capabilities of state-of-the-art technologies and compare their potential for widespread THz applications. Technologies discussed include CMOS, SiGe, InP, GaAs, GaN and AlGa<sub>N</sub>.

Speakers will describe sub-mm-wave and terahertz devices, circuits and systems currently being investigated in various technologies to demonstrate their potential, while also discussing future roadmaps. The workshop will be of interest to RFIC and IMS attendees interested in exploring the THz domain for different market sectors (commercial, defense and startups) and seeking to understand the capabilities and limitations of different technologies suitable for such applications.

The workshop will include question and answer sessions after each presentation as well as time at the end of the workshop for the audience to address questions to all the speakers.

*Speakers:*

1. “Technologies for Terahertz Science”, **Goutom Chattopadhyay**, *NASA Jet Propulsion Laboratory, USA*
2. “GaN and 2D Materials: Extreme Materials for Extreme Frequencies”, **Tomas Palacios**, *MIT, USA*
3. “GaN HEMTs and Schottky Diodes for Sub-Millimeter-Wave MMICs”, **Keisuke Shinohara**, *HRL Laboratories, USA*
4. “AlGa<sub>N</sub>/GaN Plasmonic Terahertz Detectors”, **Michael Shur**, *Rensselaer Polytechnic Institute, USA*
5. “THz Transistors: Present and Future”, **Berinder Brar**, *Teledyne, USA*
6. “Transistors for THz Systems”, **Mark Rodwell**, *University of California at Santa Barbara, USA*
7. “The Evolution and Future of SiGe Technologies for THz Applications”, **John Pekarik**, *IBM, USA*

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8. “Silicon THz: An Opportunity for Innovation”, **Ali Hajimiri**, *Caltech, USA*
9. “SiGe BiCMOS Technologies for Commercial mmWave Imaging Systems”, **Vipul Jain**, *SaberTek, USA*

**WME (Full Day): Monday 08:00–17:00**  
**High Speed Signal Integrity Workshop**

*Sponsor:*     **ARFTG**

**WMF (Half Day): Monday 13:00–17:00**

**Electro-Nanoporation: An Emerging Biomedical Electromagnetic Application**

*Sponsor:*     **MTT-10 Biological Effects and Medical Applications**

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**MONDAY SHORT COURSES – 3 JUNE 2013**

**SC-5: Monday 08:00–17:00**

**Inkjet Printed RF Electronics**

*Sponsors:*   **MTT-8 Filters and Passive Components, MTT-17 HF/VHF/UHF Technology, MTT-24 RFID Technologies**

**SC-6: Monday 08:00–17:00**

**Using CAE to Model PLL Noise and Transient Performance**

*Sponsor:*     **MTT-22 Signal Generation and Frequency Conversion**

**SC-7: Monday 08:00–17:00**

**Theory and Design of Phase Locked Loops**

*Sponsor:*     **MTT-22 Signal Generation and Frequency Conversion**

**SC-8: Monday 08:00–17:00**

**Fundamentals of Device Modeling for Nonlinear Circuit Simulation and Microwave Design**

*Sponsor:*     **MTT-11 Microwave Measurements**

## **FRIDAY WORKSHOPS – 7 JUNE 2013**

**WFA: Friday 08:00–17:00**

**Multi-Octave High Efficiency, High Linearity High Power**

*Sponsor:* **MTT-5 Microwave High-Power Techniques**

**WFB: Friday 08:00–17:00**

**SSPAs vs. Vacuum Tube Amplifiers: An Update**

*Sponsor:* **MTT-5 Microwave High-Power Techniques**

**WFC: Friday 08:00–17:00**

**Microwave Sensors and Biochips for Biomolecules and Cells Characterization**

*Sponsor:* **MTT-10 Biological Effects and Medical Applications**

**WFE: Friday 08:00–17:00**

**RFICs/MMICs and Their Professional Wireless Sensing Applications**

*Sponsor:* **MTT-20 Wireless Communication**

**WFF: Friday 08:00–17:00**

**Recent Advances on RF/Microwave Multi-Function Filtering Devices**

*Sponsor:* **MTT-8 Filters and Passive Components**

**WFH: Friday 08:00–17:00**

**Designing High-Efficiency Microwave Switch-Mode Amplifiers Beyond 2GHz**

*Sponsor:* **MTT-6 Microwave and mm-Wave Integrated Circuits**

**WFI: Friday 08:00–17:00**

**RF-on-Demand for the Internet of Things**

*Sponsors:* **MTT-26 Wireless Energy Transfer and Conversion, MTT-24 RFID Technologies, MTT-25 RF Nanotechnology**

**WFJ: Friday 08:00–17:00**

**Microwave Systems for Security Applications**

*Sponsor:* **MTT-16 Microwave Systems**

**WFK: Friday 08:00–17:00**

**Satcom and Aerospace Beyond Ka-Band: Progress and Challenges**

*Sponsor:* **MTT-20 Wireless Communication**

**WFL: Friday 13:00–17:00**

**Magnetoelectrics: An Emerging Technology for a New Class of RF and Microwave Control Components**

*Sponsor:* **MTT-13 Microwave Ferrites and Ferroelectrics**

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**FRIDAY SHORT COURSES – 7 JUNE 2013**

**SC-9: Friday 08:00–17:00**

**The Dynamics, Bifurcation, and Practical Stability Analysis/Design of Nonlinear Microwave Circuits and Networks**

*Sponsor:* **MTT-16 Microwave Systems**

**SC-10: Friday 08:00–17:00**

**Procedures and Techniques for Characterizing High-Power Devices Using Vector Network Analyzers**

*Sponsor:* **MTT-5 Microwave High-Power Techniques**

**SC-11: Friday 08:00–17:00**

**Sub-picosecond Jitter Fractional Frequency Synthesizer Design**

*Sponsor:* **MTT-22 Signal Generation and Frequency Conversion**

**SC-12: Friday 08:00–17:00**

**Graphene RF Electronics: Modeling and Applications**

*Sponsor:* **MTT-25 RF Nanotechnology**

# **SOCIAL EVENTS/GUEST PROGRAM**

**SUNDAY, 2 JUNE 2013**

**RFIC Reception: 19:30–21:30**

**Washington State Convention Center, Ballroom 6E**

Immediately following the RFIC Plenary Session is the RFIC Reception to be held in adjacent Room 6E at the Washington State Convention Center (WSSC). This social event is a key component of the RFIC Symposium, providing an opportunity to connect with old friends, make new acquaintances, and catch up on the wireless industry. Admittance is included with RFIC Symposium registration. Additional tickets can also be purchased separately at registration.

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**MONDAY, 3 JUNE 2013**

**IMS2013 Welcome Reception: 19:00–20:00**

**Sheraton Seattle Hotel**

All Microwave Week attendees and exhibitors are invited to attend a reception hosted by IMS2013 in the Sheraton Seattle Hotel, Grand Ballroom, 2<sup>nd</sup> Floor.

**Chapter Chairs' Meeting (CCM): 20:00–22:00**

**Sheraton Hotel, 3<sup>rd</sup> Floor, Metropolitan Room**

All our Chapter Chairs and their designated Chapter representatives are cordially invited to our Reception/Poster Session followed by the Chapter Chair's Meeting. For further information contact your Regional Chapter Coordinator, or Bela Szendrenyi at [bela.szendrenyi@advantest.com](mailto:bela.szendrenyi@advantest.com).

Sponsor: IEEE MTT-S AdCom and the MGA Committee

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**TUESDAY, 4 JUNE 2013**

**Women in Microwaves Reception: 18:00–19:30**

**Seattle Space Needle, 100-Level**

Meet with old friends as well as make new connections to the growing community of women who make a career in the field of high-technology. Enjoy great food, refreshing beverages and warm conversation at the WIM Social Event.

**Ham Radio Social: 18:00–19:30**

**Seattle Space Needle, 100-Level**

While enjoying a buffet and open bar, the attendees will have the opportunity to see the accomplishments of amateur radio operators who have skillfully designed and built transceivers for use from VHF to high millimeter wave bands. Some of these transceivers were made from surplus and commercially available components and some are state-of-the-

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## **SOCIAL EVENTS/GUEST PROGRAM (continued)**

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art new designs including SDR. Several will be on display and their builders will be there to answer questions.

All conference attendees are welcome. You will find that amateur radio operators are utilizing their allocated frequency spectrum for very important uses and you may be interested in obtaining your license so you too can test your new designs and microwave propagation.

### **MTT-S Graduates of the Last Decade (GOLD) and Student Reception: 19:30–21:30 Experience Music Project (EMP) @ Seattle Center**

The IEEE MTT Graduates of Last Decade (GOLD) and Student Committees invite all MTT GOLD and student members to a complimentary reception at the Experience Music Project located at Seattle Center. This will be an excellent opportunity not only to relax and entertain, but also to interact and network with other GOLD and student members.

Sponsor: IEEE MTT-S GOLD and Student Committees

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### **WEDNESDAY, 5 JUNE 2013**

#### **Industry Hosted Cocktail Reception: 17:00–18:00 Washington State Convention Center, Level 4 – Exhibition Hall**

Symposium Exhibitors will host a cocktail reception.

#### **MTT-S Awards Banquet: 19:00–22:00 Sheraton Seattle Hotel, Grand Ballroom C&D**

The MTT-S Awards Banquet includes dinner, major society awards presentation and entertainment. Tickets can be purchased at the time of registration. Entertainment will also be provided by Tom Raschko (IMS2013 General Chair) and The Jet City Band.

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### **THURSDAY, 6 JUNE 2013**

#### **MTT-S Student Awards Luncheon: 12:00–14:00 Sheraton Seattle Hotel, Grand Ballroom C**

All students are invited to attend the luncheon which recognizes recipients of the MTT-S Undergraduate Scholarships, MTT-S Graduate Fellowships, MTT-S PhD Student Initiative Program, IMS2013 Student Volunteers, IMS2013 Student Paper Awards and the participants/winners of the IMS2013 Student Design Competitions.

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## **SOCIAL EVENTS/GUEST PROGRAM** (continued)

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### **IMS2013 Closing Reception: 17:30–18:30 Washington State Convention Center, Ballroom 6A**

All Microwave Week attendees and exhibitors are invited to attend the Closing Reception hosted by IMS2013 in the Washington State Convention Center in Ballroom 6A.

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### **SUNDAY, 2 JUNE – THURSDAY, 6 JUNE, 07:00–16:30 and FRIDAY, 7 JUNE, 07:00–12:00**

#### **Guest Lounge**

The Guest Lounge will be located at the Sheraton Hotel on the Lobby Level in the Diamond Room. It will be a place to relax and meet. The Guest Lounge will also have suggestions and discount coupons for various activities to enjoy while in Seattle as well as fun games and crafts for the families. Guest registration is required and fees do apply.

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### **IMS2013 COMPANION TOURS**

Attendees should meet at the Sheraton Hotel lobby-level hospitality suite at the starting times shown below.

#### **MONDAY, 3 JUNE 2013 Premier 3-Hour City Tour (\$49) 09:45–13:00**

This Premier 3-hour City Tour is designed to give you a fantastic overview of Seattle. Sit back and relax in the spacious Tours Northwest coach as our knowledgeable and friendly guide acquaints us with some of Seattle's most interesting neighborhoods and attractions. Sights are numerous and include Pike Place Market, the Seattle waterfront, CenturyLink Field and Safeco Field stadiums, Mercer Island via the floating bridge, the International District, the Fremont neighborhood with its famous Troll, and Seattle's not-to-be-missed landmark Space Needle. Along this 50-mile tour we'll make a stop at historic Pioneer Square, which marks Seattle's original downtown, and also at the Ballard Locks, which provide a passage for boats going between the salt water of the Puget Sound and the fresh water of the Ship Canal. You can also enjoy the underwater viewing at the adjoining salmon ladders. Near the end of our tour we'll have a great city skyline photo opportunity.

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## **SOCIAL EVENTS/GUEST PROGRAM** (continued)

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**TUESDAY, 4 JUNE 2013**

**Savor Seattle Pike Place Market Tasting Tour (\$45)**

**First tour — 08:45–11:30**

**Second tour — 09:15–12:00**

Become a Pike Place Market insider on our 2-hour, behind-the-scenes adventure. Experience the sights, sounds, and flavors of this 105-year-old landmark while seeing fish fly, cheese being made, and visiting the original Starbucks. Bring your appetite because we'll be treated to at least sixteen tasty samples including crab cakes, chowder, and cheese. We'll be given an insider's look at ten of the Market vendors and hear entertaining stories of the Market's rich history and culture. After our guided tour, you may want to extend your visit and shop among the many craft vendors selling locally-made jewelry, clothing, and gifts.

**TUESDAY, 4 JUNE 2013**

**Fairmont High Tea (\$55)**

**12:30–15:00**

Enjoy a traditional Afternoon High Tea at the historic Fairmont Olympic Hotel. In addition to a fine selection of teas, you will enjoy tea sandwiches, savories, and house-made scones. It will be a relaxing afternoon as we luxuriate in the beautiful setting of the Georgian restaurant's high ceilings, Palladian windows, and spectacular chandeliers.

**WEDNESDAY, 5 JUNE 2013**

**Space Needle and Chihuly Garden and Glass (\$40)**

**10:00–15:00**

On today's outing we'll be whisked through downtown Seattle via monorail to Seattle Center, home of the iconic space Needle, built for the 1962 World's Fair. We'll ride the elevator up to the observation deck and take in 360 degrees of awesome views of the city and Puget Sound. Lunch will be on our own at a choice of onsite restaurants. Then we'll tour the Chihuly Glass and Garden, opened just last year, where we'll learn why Seattle is so renowned for its art glass. And, we'll have ample time for the gift shops before our return trip by monorail to downtown Seattle.

**THURSDAY, 6 JUNE 2013**

**Snoqualmie Falls and Wine Tasting Tour (\$92)**

**includes: Tours Northwest coach, lunch, and wine tastings**

**09:15–15:30**

Today's tour begins with a drive to one of Washington's most popular scenic attractions, Snoqualmie Falls. From the observation deck we'll be able to view the spectacular falls cascading through a rocky gorge to a pool 270 feet below. While there, we'll also enjoy a peek in at the Salish Lodge & Spa, a quintessential Pacific Northwest retreat. Then it's on to lunch at Purple Café in Woodinville, a restaurant that combines classic American styles with seasonal Northwest ingredients. After lunch we'll tour Chateau Ste. Michelle, Washington's oldest and most acclaimed winery, gracefully

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## **SOCIAL EVENTS/GUEST PROGRAM (continued)**

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situated in beautiful park-like grounds. Your wine knowledge will be enhanced as you learn about their heritage, get an exclusive glimpse at winemaking, and pause to sample their wines. And, you'll love perusing their lovely gift shop. We'll end our day with a contrasting experience by making a visit to the contemporary Novelty Hill + Januik Winery. Here, two independent wineries share a tasting room and the talents of Mike Januik, their acclaimed winemaker. Note: This tour is for those aged 21 and older.

**FRIDAY, 7 JUNE 2013**

**Mount Rainier Tour (\$98)**

**07:00–18:00**

Be sure to bring your camera with you on your full-day Tours Northwest outing to the breathtakingly-beautiful Mount Rainier National Park. You will delight in its vast expanses of pristine old-growth evergreen forests, magnificent rivers, mountain lakes, waterfalls, and wildlife. Mount Rainier, which ascends to 14,411 feet above sea level, stands as an icon in the Washington landscape. You'll appreciate the beauty of this stunning mountain up close, and you'll be able to see the glaciers radiating from its summit. There is an informative Visitor Center with panoramic views and a movie presentation on the park and its history. Snack and gift shops can be found at the Visitor Center and the beautiful Paradise Inn. Comfortable walking shoes and layered clothing are advised. Lunch is on your own.

**TUESDAY, 4 JUNE 2013 (\$59) & THURSDAY, 6 JUNE 2013 (\$59)**

**The Future of Flight Aviation Center and Boeing Tour**

**07:45–12:00**

The Future of Flight Aviation Center and Boeing Tour offers the only opportunity to tour a commercial jet assembly plant in North America. We'll travel by Tours Northwest coach to the Future of Flight Aviation Center located in Mukilteo, Washington, 25 miles north of Seattle. You'll be able to explore the interactive exhibits and displays and will even have the opportunity to design and virtually test your own jet. Then, after a short video presentation, we'll go behind the scenes at nearby Boeing's Everett, Washington facility for a fascinating 90-minute tour of the world's largest building by volume (472,000,000 cubic feet). Home to the 747, 767, 777, and 787 Dreamliner production lines, you'll see airplanes in various stages of construction being built for their worldwide base of airline customers. And, who knows? You might be flying on one of these very planes some day!

IMPORTANT: Please note all restrictions on Boeing website before signing up(<http://www.boeing.com/commercial/tours/index.html>)

**THURSDAY, 6 JUNE 2013**

**Thursday Night Event (\$55)**

**Seattle's Premier Native Cultural Experience and  
Home of the Famous Salmon Bake at Tillicum Village**

**18:00–22:30 (departs from Pier 55)**

Begin your 4-hour escape with a narrated cruise from downtown Seattle, Pier 55 to Blake Island State Park. Upon

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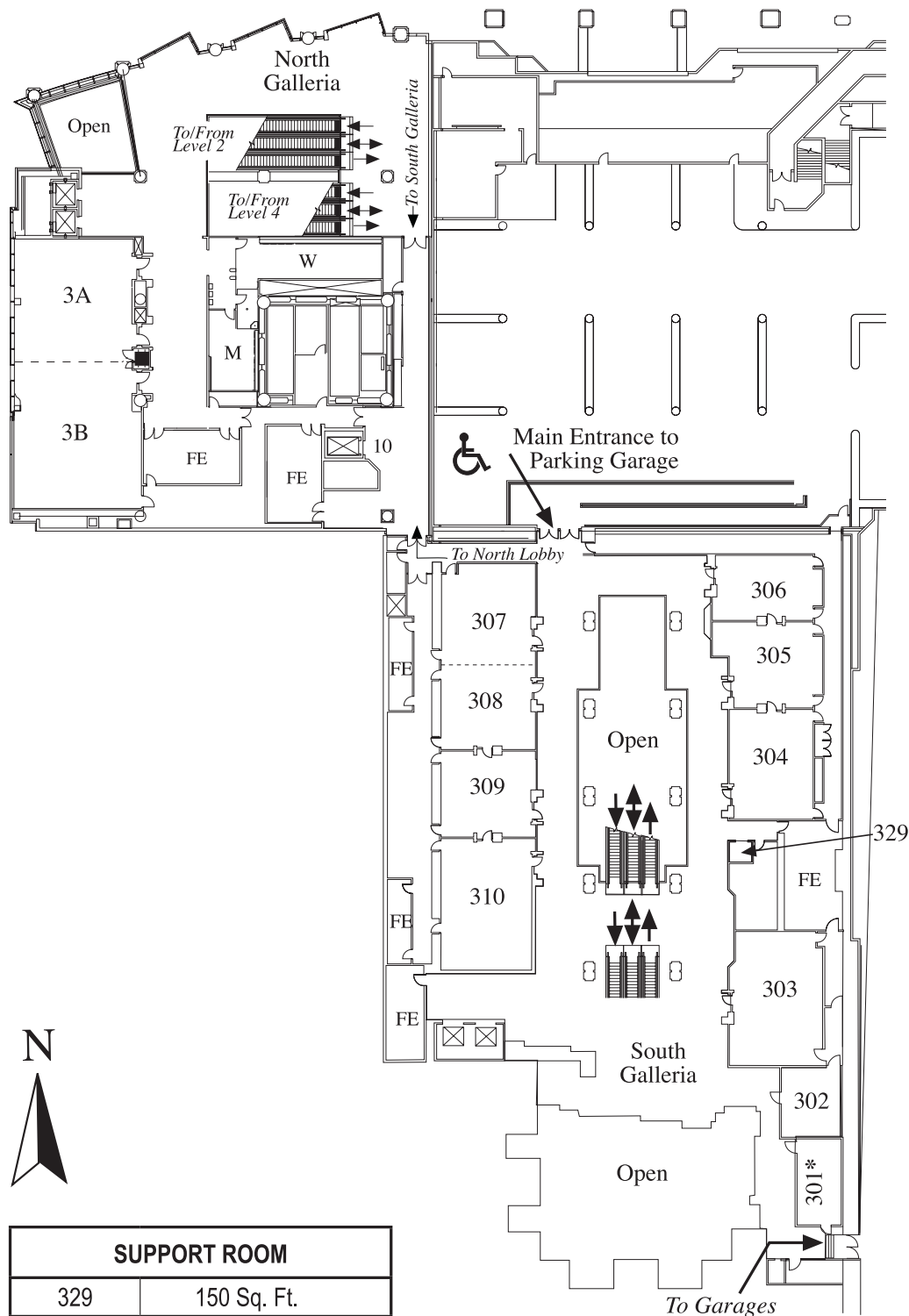
## **SOCIAL EVENTS/GUEST PROGRAM** (continued)

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arrival to Tillicum Village, you are greeted with steamed clams in nectar. Make your way into the longhouse and watch as whole salmon are cooked in a traditional Northwest Coast Indian style. Enjoy a fabulous salmon buffet meal followed by a show that highlights the Coast Salish tribes through storytelling and symbolism. Afterward, you'll have free time to explore the grounds and gift shop before returning to Seattle.

# CONVENTION CENTER MAPS

## Level Three: Meeting Rooms





# CONVENTION CENTER MAPS (continued)

## Level Six: Ballrooms & Meeting Rooms

