Workshops and Short Courses

Bobby Weikle, Walid Ali-Ahmad, Antonio Raffo, and Huseyin Arslan



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Workshops and short courses provide attendees of the IEEE Microwave Theory and Techniques Society (MTT-S) International Microwave Symposium (IMS), Radio Frequency Integrated Circuit (RFIC) Symposium, and Automatic RF Techniques Group (ARFTG) Conference, and the Wireless and Microwave Technology Conference (WAMICON) the opportunity to gain introductory to expert-level knowledge in focused areas of interest. The workshop program consists of half-day and full-day sessions that draw speakers who are recognized experts in their respective fields. Depending on the duration, sessions typically host between four and eight speakers. Each speaker presents on a topic related to the central theme of the workshop, and the slate of speakers often provides contrasting perspectives. A distinct emphasis of the workshops is to facilitate and provide significant interaction between speakers and attendees than in formal paper sessions, and this allows for greater dialog between the speakers and audience. This degree of group interactivity creates an opportunity for IMS attendees that is not only unique to the workshop sessions but serves as a valuable vehicle for exploring new and emerging areas in depth.

Short courses have a different goal and format than workshops. Typical short courses include comprehensive instructional content guided by a set of defined learning objectives, often supplemented with laboratory demonstrations. Short course sessions are usually between a half day and full day in duration and are led by one or two expert instructors covering the topic. This focus and format generally allows for significantly greater depth in the coverage of a topic than the workshop or paper sessions can provide. Short courses provide a valuable opportunity for IMS attendees to explore important areas and engage with leading experts in the microwave/RF community.

We are excited to offer 34 workshops and four short courses for the MTT-S Microwave Week agenda. As part of Microwave Week, many of these workshops are cosponsored by the conferences adjoining IMS, namely, RFIC, ARFTG, and WAMICON conferences. High-level overviews are provided for the workshops and short



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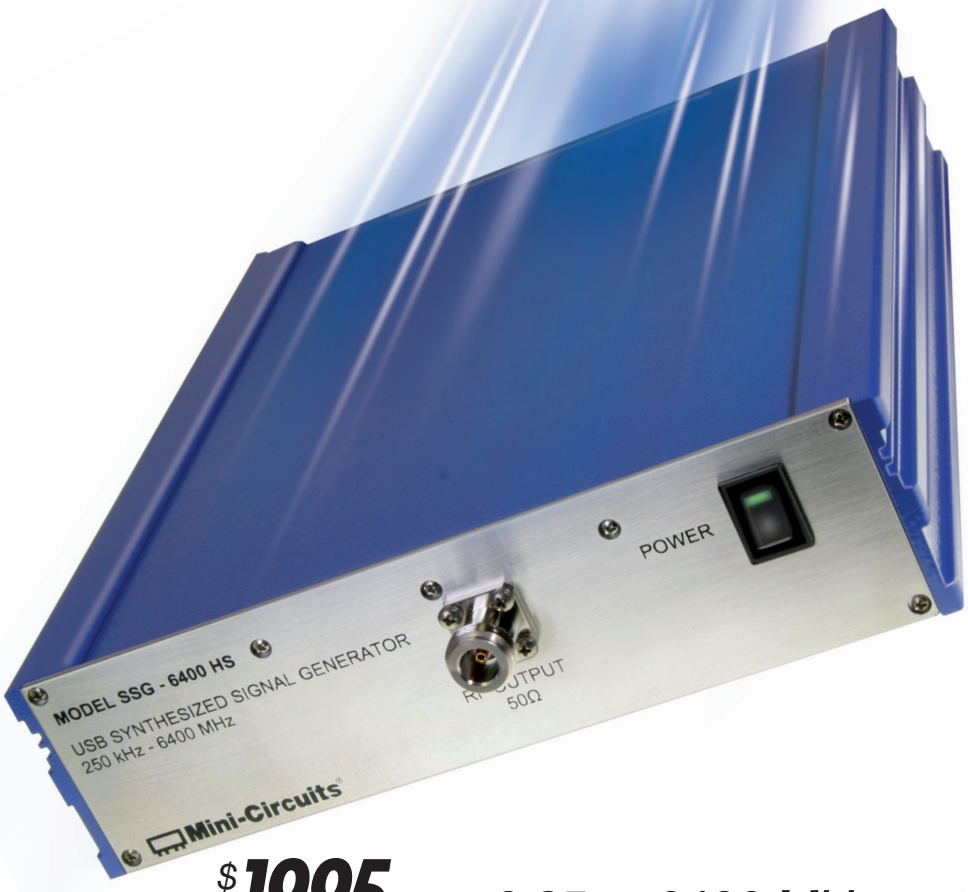
Workshops offer the opportunity for attendees to advance their knowledge.

Bobby Weikle, Walid Ali-Ahmad, Antonio Raffo, and Huseyin Arslan are the IMS2014 Workshop and Short Courses cochairs.

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Table 1. Workshops for Microwave Week 2014.

	CODE	Title/Organizers
Sunday	WSA	**Silicon and GaN PA for RF and mmW Applications (RFIC/IMS)** *Drs. Didier Belot and Eric Kerhervé* Silicon power amplifiers (PAs) are dedicated for RF applications with high-power and/or high-linearity requirements and for millimeter-wave with high-power added efficiency, medium linearity, and medium to high power requirements. At the same time, new digital-like architectures for RF require class E, class F, RF-DAC power devices, while in millimeter-wave, first millimeter-wave-DAC architectures are ongoing. Where is the limit? Can we imagine pure digital transmitter with such PAs? Which technology could answer these challenges? Do we need multi-technology modules? What is the best cost/efficiency compromise? This workshop will overview state-of-the-art technologies, design and system evolution to address these questions.
	WSB	**PAs for Software-Defined/Cognitive Radio (RFIC)***Drs. Jeffrey S. Walling and Hongtao Xu* Software-defined and cognitive radio backends are becoming more prevalent, while the RF front-end hardware used to transmit such SDR and CR signals are constrained to multi-band architectures with independent front-end gain and filtering. Bandpass data converters have proven adept at operating over multiple communications standards and a wide range of frequency, but the transmitter lags behind. The RF PA is a key element to enabling more portable solutions in SDR, but remains challenging to implement because most PAs use narrowband matching networks that limit their use over a wide range of frequencies. Furthermore, such PAs are not readily reconfigurable from one standard to the next due to differing fidelity requirements. This workshop presents techniques to improve efficiency over a wide range of modulation standards, using techniques such as DPA, SCPA, outphasing, etc. Pathways toward multiband PAs will also be presented using techniques such as wideband matching and new materials.
	WSC	**GaN-Based Power Supplies and Power Supply Modulators for Efficient Powering of RF PAs (RFIC)** *Drs. Ayman Fayed and Jennifer Kitchen* Efficient operation of RF PAs is a strong function of the power conversion efficiency of the power supplies used to deliver power to these PAs. Therefore, the design of highly-efficient switching power supplies and power supply modulators for these PAs is of utmost importance. A key aspect of designing switching power supplies is the devices used to implement the power switches. GaN devices have great potential to fulfill that role, mainly due to their ability to handle high voltage and current levels while maintaining very low on resistance and relatively low gate capacitance compared to silicon counterparts. This workshop will cover four important aspects of designing switching power supplies using GaN devices: 1) the physics of GaN devices and how GaN devices compare to other technologies such as Si and GaAs, 2) the design of gate drive circuits for depletion-mode GaN power switches, 3) the design of static switching power supplies using enhancement-mode GaN power devices, and 4) the design of switching and hybrid power supply modulators using GaN devices.
	WSD	**Techniques for Handling Interference and Self-Interference (RFIC)** *Drs. Danilo Manstretta and Eric Klumperink* Interference handling, but also self-interference handling, is increasingly becoming important in radio receivers. On the one hand this is because the number of wireless devices is steadily increasing, increasing the probability that a nearby strong interferer exists. On the other hand extra interference and also self-interference occurs because multiple radios have to co-exist in one user terminal, preferably with less external components. In systems that transmit at the same time but at different frequency, duplexer filters can be used to suppress self-interference. To maximize data throughput and spectral efficiency further, it might be beneficial to not only transmit and receive at the same time but also at the same frequency. However, such full-duplex communication causes very strong self-interference, and techniques to reduce this are very much wanted. Such techniques can also relax duplex filter requirements, also creating new possibilities in half-duplex radio architectures. This workshop will review techniques to reduce interference and self-interference. Several recently proposed techniques that can contribute to improving interference and self-interference handling will be reviewed.
	WSE	**Coupling and Interference in Integrated Circuits: EMC/EMI-Aware Design Practices (RFIC/IMS)** *Drs. Rick Janssen, Oren Eliezer, and Naveen Yanduru* With the integration of RF, mixed signal and digital building blocks on a single die, combined with the trend to go to higher frequencies to accommodate for higher data rates, it is essential to consider various on-chip coupling effects during the design phases of the IC. Additionally, measures should be taken at the system/application level to reduce the impact of peripheral interactions (between chip, package, pcb, antenna, etc.), as well as the potential for self-interference, such that these are either eliminated or can be resolved on the fabricated product, thereby reducing the number of re-spins. Also, more and more present-day products have to pass rigorous EMC tests to confirm compliance with standards (to ensure performance of the complete system under a wide variety of conditions). The focus of this workshop will be addressing these EMC/EMI problems by applying the proper simulation methodologies during the design phase. This includes making use of dedicated EDA capabilities to predict EMC/EMI, as well as applying design methodologies and approaches that allow for the mitigation of self-interference effects.

(continued)

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KEYNOTE



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Vida Ilderem - *Vice President, Intel Labs;*
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Table 1. Workshops for Microwave Week 2014 *(continued)*.

CODE	Title/Instructors
WSF	**MEMS-CMOS Integration (IMS/RFIC)** ***Drs. James C. M. Hwang and Joachim Oberhammer*** This workshop focuses on the rapidly evolving field of MEMS-CMOS integration for commericalization of RF MEMS. The integration can be homogeneous or heterogeneous. Homogeneous integration on wafer scale takes advantage of the mature CMOS backend processes and post-processing to improve the yield, cost, robustness and reliability of MEMS. Alternatively, integration can be done heterogeneously in-package or at the circuit level, using CMOS circuits to intelligently control MEMS or using MEMS to switch CMOS circuits with high on/off ratios. The first part of the workshop will focus on new and innovative ideas for successfully commercialized CMOS-backend-integrated MEMS. The second part of the workshop will focus on new and innovative ideas for IC integration of RF MEMS. In both parts of the workshop, the limitations of CMOS-integrated RF MEMS will be critically reviewed and different approaches to overcome such limitations will be explored.
WSG	**Advanced SiGe and CMOS Phased Array Systems from 3 to 100 GHz (IMS/RFIC)** ***Drs. Gabriel M. Rebeiz and D. M. Leenaerts*** SiGe and CMOS technologies have permanently changed the way phased arrays are built by integrating the complex back-end functions into a single chip and by integrating many channels on the same chip. These complex back-end chips also enable the construction of multiple-beam array, something that was considered nearly impossible with GaAs T/R modules. This work started at the university level but quickly transferred to industry, and today, there are several efforts in industry from 3 GHz to over 100 GHz using a silicon back-end. This workshop will present recent demonstrations of such systems, from academia, industry and government perspective.
WSH	**How Digital Can RF Go? (RFIC)** ***Drs. Gernot Hueber and Robert Bogdan Staszewski*** Advances in fabrication technology have enabled the use of CMOS technology in today's RF transceivers for wireless communications. Multi-band and multi-mode radios covering a wide diversity of communication standards impart unique challenges on the RF-transceiver design due to limitations in reconfigurable RF components capable of meeting the demanding cellular performance criteria at costs attractive for mass market applications. Nanoscale CMOS, on one hand, features the possibility for implementing a significant computational power and complex functionality directly on a single IC. On the other hand, it shows poor performance in RF circuits compared to other technologies. The focus of this workshop is on the challenges of RF transceiver design and architectures in nanoscale CMOS, along with a thorough discussion of advanced techniques for receivers and transmitters towards integration in a multi-radio SOC or SIP. 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.
WSI	**Wireless Power Transfer and Wireless Charging (RFIC)** ***Drs. Gernot Hueber and Magnus Wiklund*** Wireless power transfer and wireless charging is becoming a technology on the way to deployment in the high-volume market from mobile devices (smartcards, phones, tablets) to electric vehicles and many other areas. The interest of the RFIC community is to explore technological challenges and boundaries of what our modern integrated circuit processes has to offer, which architecture and how to design on the circuit level. RFIC development of circuits is a highly advanced topic and this workshop will address devices from both system and circuit design level as well as testing.
WSJ	**Reconfigurable Radio-Frequency Transceivers (RFIC)** ***Drs. Hossein Hashemi and William Chappell*** Modern commercial and military wireless systems should support various waveforms and standards under dynamically changing electromagnetic environments. A straightforward software-defined radio (SDR) enables changing the radio parameters, such as carrier frequency, modulation format, and signal bandwidth, in a fixed architecture, through software. A more advanced reconfigurable radio enables changing the architecture of the transceiver and/or the individual building blocks to optimize the performance while minimizing the power consumption. Architectural level reconfigurability reduces the nonrecurring engineering (NRE) cost associated with the design of a new transceiver tailored to a specific application. Moreover, dynamic adjustment of radio architecture and specifications can be in response to, for instance, varying signal, noise, and interference levels. This workshop covers the latest developments in the design and implementation of reconfigurable wireless transceivers.

(continued)

Call for Papers

Topical Symposium on

Power Amplifiers for Wireless Communications

September 15th & 16th, 2014
San Diego, CA

Power amplifiers are a vital enabling technology for wireless communication systems, and are evolving rapidly under the dual pressures of providing improved efficiency and improved linearity in support of higher capacity. This meeting, to be held in late summer in San Diego, provides a forum for innovative work in the area of power amplifiers, including requirements for and accomplishments in amplifiers for both uplink and downlink.

Papers are solicited in (but not limited to) the following areas:

- Devices for power amplifiers: Si and III-V semiconductors
- IC technology for power amplifiers
- Modeling and design techniques for power amplifiers
- High efficiency architectures with supply or load modulation
- System requirements and transmitter architectures
- Linearization and Pre-distortion techniques
- Measurement techniques
- Circuits for LTE, WiFi, and mm-wave transmitters for networks from PAN to WAN

Invited papers highlighting state-of-the-art developments from around the world will also be presented.

Instructions for Authors: Prospective authors are requested to submit by email a 2 page abstract (one page text, with approximately 500 words, and one page figures) clearly describing the novel features of their work to **James Buckwalter** at **buckwalter@ece.ucsd.edu**. *Abstracts of accepted papers will be distributed at the conference; however, the publication is not archival, and authors are encouraged to resubmit to journals.*

Type of Submission	Submission Deadline Date	Acceptance Notification Date
Early Acceptance	June 6th, 2014	June 20th, 2014
Normal Acceptance	July 18th, 2014	July 25th, 2014

Conference Executive Committee:

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Table 1. Workshops for Microwave Week 2014 *(continued)*.

	CODE	Title/Instructors
	WSK	**Frequency Synthesis For 60-Ghz and Beyond: Architectures and Building Blocks (RFIC)** ***Drs. Stefano Pellerano and Jeyanandh Paramesh*** Synthesizing local-oscillator (LO) signals with high-spectral purity within an integrated circuit can be a challenging task and has been the focus of many researchers for decades. Other aspects, such as high-oscillation frequency, low-power consumption, wide tuning range/frequency modulation, and relatively low quality factor passives, make the design even more daunting. This workshop focuses on the latest state-of-the-art advancements on how to efficiently synthesize LO signals from 60 GHz up to sub-THz frequencies for applications such as wireless communications, radar and imaging. Overall synthesizer architecture and building block details will be considered, with particular attention to oscillator design. Techniques for reducing power consumption and phase noise while increasing tuning range will be addressed and the latest advancements in injection-locking and frequency division/multiplication will also be presented.
	WSL	**Ultra Low Power, Low Cost Radios (RFIC)** ***Drs. Sudipto Chakraborty and Oren Eliezer*** There has been a growing interest in minimizing the power/energy consumption and the cost of integrated radios for various applications that are battery operated and/or harvest energy from the environment. Successful development of ultra-low power and low cost radios requires that different aspects of the design be properly addressed. These include consideration of relevant standards, overall system design and radio system architecture, circuit design techniques, minimal external component count, and low cost testing. Several standards, such as Bluetooth low energy (BLE), ZigBee, ANT, and BAN, have been proposed in the past years to address the growing needs of various personal area communication systems. These solutions primarily target sports monitoring, body area networking, remote structural health monitoring, wireless sensors, and various other emerging applications. This workshop addresses various system and circuit design techniques that serve to augment the dynamic range per unit power consumption of integrated radios, while achieving a low cost solution. Industry and academia experts will present a wide variety of topics, ranging from low-data-rate radios operating at sub-MHz frequencies, to high-data-rate radios operating at millimeter-wave frequencies.
	WSM	**RF and Wideband Data-Converters for Transmitters and Receivers (RFIC)** ***Drs. Gaurav Chandra, Harish Krishnaswamy, and Oren Eliezer*** As RF transceivers continue to be integrated into digital SoCs, in which multiple radio standards and frequency bands are covered, there is increased motivation for realizing the digital-to-RF and RF-to-digital conversions in ways that are more amenable to integration in such environments. More specifically, the preferred implementations are extensively digital in nature, as digital resources can be assumed to be readily available and can serve for digital-signal-processing based calibration and compensation. This workshop, involving experts from industry and academia, will cover various architectures and techniques for digital-to-RF conversion, that are to be used at the transmitter end, as well as efficient and configurable RF-to-digital converters to be used at the receiver end. Additionally, wideband data-converters, such as pipelined ADCs and interleaved DACs, which may serve in wideband transceivers, will be covered.
	WSN	**Characterizing the Impact and Benefits of Millimeter Waves on Biomaterials (IMS)** ***Drs. M.R. Tofighi and D. Schreurs*** Due to the crowded spectrum in the lower microwave range, the interest in mass-market applications at millimeter wave frequencies is growing; e.g., 60 GHz LAN, 79 GHz automotive radar, etc. Whereas much attention has been paid in the past on studying the interaction of microwaves (< 5 GHz) on biomaterials, e.g., the impact of cellular phones' radiation on human head, this research is now evolving towards millimeter wave frequencies (>30 GHz). This workshop focuses on characterizing the interaction of millimeter waves and biomaterials, covering biological tissues and liquids. Measurement challenges, as well as the benefits of such characterizations in biomedical applications, will be addressed.
Monday	WMA	**Modern RF-Module Design: Integrated Forms of Silicon and Gallium Nitride (IMS)** ***Drs. Ruediger Quay, Frank Sullivan, John Pierro, and Tim Lee*** This workshop is focused on recent developments of transmit and receive modules and integration based on the advances in silicon and gallium nitride IC technology. The technologies emerging for this application, such as SiGe, BiCMOS, and CMOS, in combination with more integrated and higher functional GaN enable significant architectural changes in the race for performance and cost that have limited the applications space. The workshop will address the progress, design, trade-offs, and remaining issues arising from the combinations of GaN and the use of Si as well as the resulting possible improvements in array technology starting from technology to system aspects.
	WMB	**Highly Efficient PAs and Smart Transmitters (IMS/RFIC/WAMICON)** ***Drs. Renato Negra and Georg Boeck***

(continued)

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Table 1. Workshops for Microwave Week 2014 *(continued)*.

CODE	Title/Instructors
	The wireless communication community has always been looking for efficient linear amplification systems. This workshop addresses the most recent activities, achievements and future possibilities in the area of highly efficient microwave PAs and advanced transmitter architectures for wireless applications. The presentations will span from circuit design to system level and introduce both progress in the design of highly efficient power stages using harmonic matching, supply modulation and load modulation concepts, as well as their application in digital-centric flexible transmitter architectures. Special emphasis is on transmitters beyond the state-of-the-art technology of envelope tracking. The principles of pulse shaping, outphasing and active load-pulling transmitter architectures will be introduced and their potential and characteristics will be illustrated through practical implementations and measurement results. An emphasis on critical issues and limitations in realizing these amplifiers and systems will be given.
WMC	**Efficient RF Design using Practical Behavioral Models–Bridging the Gap between Measurement and Simulations (ARFTG/IMS)** ***Drs. Nuno Borges Carvalho and Marc Vanden Bossche*** Behavioral modeling is a topic that has been researched extensively in the PA areas Different techniques, including large-signal S-parameters, Volterra approaches, and envelope domain have been developed while new trademark solutions are changing the way industry looks at behavioral models. Still, confusion remains about the role and positioning of these different techniques. Recently behavioral modeling tools have moved to other areas in the wireless community, such as energy harvesting and wireless power transfer devices. To realize a meaningful acceptance of behavioral modeling techniques, the models should be easy to use, easy to extract and should describe the behavior of the devices and systems in the best way possible, while being simple and intuitive. This workshop brings together the modeling approaches, the instrumentation for parameter extraction and the simulation environments and will position the different techniques against the application space, explaining their capabilities and limitations. The workshop will conclude with a practical component, with vendors who will allow the attendees hands on experience with a real behavioral model test bench.
WMD	**Recent Developments in Low Noise and Front-End Technology, Design, Circuits, Measurement Techniques, and State-of-The-Art Applications (IMS)** ***Drs. Murat Eron and Ajay K. Poddar*** This workshop covers topics related to low noise, including low noise devices, low-noise active and passive circuits, tunable oscillators, phase-locked reference frequency signal sources, low noise amplifiers, mixers, measurement techniques and state-of-the-art applications in modern communications systems. Presenters will cover low noise circuit design techniques, robust high-performance LNA design, state-of-the-art hybrid and MMIC designs, RF-MEMS resonator based oscillators, selection of noise sources, their calibration and maintenance, low phase noise techniques and related state of the art circuit designs and measurement accuracy issues related to phase noise testing using commercially available signal source analyzers.
WME	**Recent Advances in Radar Indoor Sensors, Wireless Implantable Devices and Biosensors (IMS/WAMICON)** ***Drs. Changzhi Li, Roberto Gómez-García, Tzyy-Sheng Horng, and Olga Boric-Lubecke*** In the last few years, much effort has been directed towards the development of sophisticated RF/microwave wireless sensors for emerging biomedical-related applications. Examples include non-invasive vital-signal measurement methodologies in bio-medical scenarios, robust wireless positioning procedures, advanced occupancy-sensing techniques, novel implanted devices for in vivo monitoring and lab-on-a-chip biosensors. The aim of this workshop is to report recent research findings in this promising area of wireless sensing. This covers the latest advances in the exploitation of microwave/wireless systems for a variety for bio-medical scenarios, for example, cardiopulmonary detection, gastrointestinal monitoring, and biomolecules and cells characterization. New applications of wireless sensors beyond healthcare, such as occupancy sensing, localization, and insect monitoring, will also be presented.
WMF	**Physics-Based Nonlinear Compact Transistor Modeling for Mm-Wave Applications (IMS)** ***Drs. Paulius Sakalas and Michael Schroter***

(continued)

Table 1. Workshops for Microwave Week 2014 *(continued)*.

	CODE	Title/Instructors
		Efficient circuit design requires compact models (CMs) for the various electronic devices used. Among those, transistor CMs are the most complicated and computationally expensive ones. To allow circuit optimization and statistical design, CMs should accurately capture the device characteristics over a sufficiently wide bias, frequency, temperature, and device geometry range. As transistors are inherently nonlinear, their large-signal behavior has to be modeled consistently with their small-signal and DC behavior to predict the circuit performance in time and frequency domains correctly. The trend of achieving higher bandwidths by moving to higher frequencies has pushed technology development into the realm of mm-wave and THz transistor operation. With the advance of technology performance, the importance of accuracy and predictive capability of CMs has been increasing. The overall goal of this workshop is to provide an overview of today's most advanced large-signal physics-based and most widely used compact models along with the associated methods for model development and verification. Since the emphasis is on mm-wave and THz device operation and applications, the corresponding process technologies to be covered are SiGe HBTs, InP HBTs, III-V materials.
	WMG	**Current Trends in mm-Wave Integrated Circuits and Integration Techniques (IMS)** ***Drs. Kamal K. Samanta and Maurizio Bozzi*** This workshop presents recent advancements and novel achievements in millimeter-wave monolithic and hybrid integrated circuits and integration technologies and techniques to realize high-performance and compact RF frontends for emerging applications. The current trends and state-of-the-art developments in monolithic circuits (MMIC), including those based on InP, GaN, SoI and SiGe will be discussed. In addition, emerging approaches for mm-wave circuit and system integration (MIC and MCM) will be presented including packaging issues, substrate integrated waveguides and the use of multilayer technologies such as, liquid crystals polymers (LCP), photoimageable thick-film, organic and low-temperature cofired ceramics (LTCC).
	WMH	**System-On-Chip and System-On-Package for Mm-Wave Communication and Imaging (IMS/RFIC)** ***Drs. Arun S. Natarajan and Pierre Busson*** Several communication and imaging applications at mm wave require large element arrays for increased data rates and resolution. The feasibility of silicon integration of large number of elements at mm wave has been shown in recent years. Packaging and measuring such multiple antenna systems in V band and W band, particularly at low cost for widespread commercial applications, presents interesting challenges. Several approaches are being explored, including antenna-in-package and o-chip antennas with off-chip dielectric slabs/lenses. This workshop will focus on design and measurement techniques for co-integration of mm wave ICs with mm wave antennas and packages. Leading researchers from academia and industry will present state of the art system-level integration and testing of multiple antenna mm wave systems for 60 GHz communication and W-band imagers as well as discuss challenges and benefits of different technologies and approaches.
	WMI	**Challenges and Advances in Wafer-Level Calibration and Characterization at Millimetre and Submillimetre Wave Frequencies (ARFTG/IMS)** ***Drs. Marco Spirito and Andrej Rumiantsev*** Recent years have seen the development of several technology platforms (silicon and III-V based) capable of providing maximum oscillation frequencies in the upper mm-wave and sub-mm-wave range. The potential opened by these technologies have triggered research efforts worldwide, resulting in extensive development of building blocks and entire systems operating at these high frequencies. Nevertheless, the quality of the on-wafer measurement has not kept the pace with the technology developments. Characterization techniques at mm-wave and sub-mm-wave are bounded by the limitation of the measurement setups in terms of dynamic range, spurious generation, multimode propagation within the calibration substrates and the generally higher losses of the interconnects. This workshop reports on the approaches used by several groups pushing the state of the art of measurement technology and will focus on issues including interfaces with the on-wafer environments, wafer-probing in the sub-mm-wave bands, wafer-level calibration, an dmode dispersion in electrically thick calibration substrates.
Friday	WFA	**Revisiting Equivalent Circuit Models for Emerging Technologies: from Microwaves to THz** (IMS) ***Drs. Jan Machac and Francisco Mesa*** Equivalent circuits of microwave passive structures have been and still are an important topic. The equivalent circuits composed of lumped elements and/or transmission line segments represent a significant tool that helps to understand the behavior and physics of corresponding microwave structures or elements. Particular aspects of equivalent circuits that will be addressed in the workshop range from the general theory and rules to the knowledge of how to build these circuits and their applications. The workshop will cover the application of established methods to novel structures (THZ and nanoplasmonic components, special surfaces and metasurfaces, metamaterial-based transmission lines) as well as new approaches developed for handling present and emerging technologies. (continued)

Table 1. Workshops for Microwave Week 2014 *(continued)*.

CODE	Title/Instructors
WFB	**Frequency Agile Antennas and Sensors Using Advanced Control Materials (IMS)** ***Drs. Anton Geiler and Thomas Lingel*** Reconfigurability, frequency agility, and other innovative capabilities and enhanced performance have become possible with the remarkable progress made in ferrimagnetic, ferroelectric, phase change materials, and superconducting arrays. This workshop will address technological advances made possible by low-loss temperature-compensated microwave materials with enhanced dielectric constants, innovative magnetic materials and design concepts, ultra-fast metal-insulator transitions in phase change materials that are showing great promise for future modulators and other communication components.
WFC	**Microwave Photonic Integrated Circuits and Systems: Opportunities and Challenges Offered by Graphene and Silicon (IMS)** ***Drs. Thas A Nirmalathas, Dalma Novak and Rod Waterhouse*** Graphene has emerged as a potential material candidate allowing interesting possibilities enabling optoelectronic and high-frequency analog electronic devices to be integrated on the same platform. In a similar vein, Silicon (Si) Photonics has been touted as a technology that can result in low cost, highly integrated, high-speed photonic transceivers leveraging the low cost CMOS semiconductor infrastructure. This workshop will break new ground in bringing together researchers and technologist working in the fields of Graphene electronics, optoelectronic integrated circuits and microwave photonics to discuss the possibilities offered by rapidly developing material platforms. Participants will obtain an overview of Graphene in terms of its general high-speed properties as well as its suitability for realizing optoelectronic circuits. Participants will also be provided with an overview of Si Photonics, including the challenges involved with the wide scale adaption of this technology.
WFD	**Statistical Modeling of Microwave Circuits and Systems (IMS)** ***Drs. Costas D. Sarris and Peter Aaen*** Research on microwave computer-aided design (CAD) tools has been dedicated to the simulation of arbitrarily complex yet well-defined structures. However, micro- and nanofabrication tolerances often play an important role in the performance of both microwave circuits and the overall system architecture that they belong to. Notably, as device miniaturization progresses, fabrication process variability grows; as a result, the geometry and the operation of transistors and interconnects becomes subject to statistical uncertainty, creating a "red brick" problem for the microelectronics industry (*IEEE Spectrum*, July 2012). For years, statistical uncertainty in high-frequency circuits had been analyzed by post-processing data from repetitive simulations. Not surprisingly, this approach is extremely time consuming and hardly within the time constraints of a typical engineering design cycle. This workshop is aimed at bringing together academic researchers, commercial software developers and industry users of software tools to explore the state of the art in new algorithms that offer a fresh perspective to this old problem.
WFE	**Recent Advances in Space Mapping Modeling and Optimization (IMS)** ***Drs. Qingsha S. Cheng and John W. Bandler*** This year marks the 20th anniversary of the birth of space mapping technology. New applications have been expanding in traditional microwave areas and are quickly spilling into multi-physics and multi-disciplinary areas. Space mapping technology is a modeling and optimization tool that strategically enhances the accuracy of "coarse" models with few fine model training points. This workshop will address new developments towards effective model alignment and enhancement of space mapping and examples from different fields will be provided to illustrate space mapping working effectively in diverse applications.
WFF	**MIMO Radar Techniques and Frontends for Localization and Imaging (IMS)** ***Drs. Nils Pohl and Andreas Stelzer*** While the first ideas date back nearly 40 years, the concept of spatial multiplexing and approaches to MIMO (Multiple Input Multiple Output) technology appeared in patents and literature in the last decade of the last century. Several years ago MIMO realizations for wireless communications, e.g., HSPA, WLAN, and LTE entered the consumer market. Radar systems as well strongly profit from MIMO in terms of increased efficiency and performance, especially imaging applications using massive MIMO. However, the generally higher operating frequencies and bandwidths of radar systems compared to communications systems lead to a higher complexity of the frontend and signal processing, which makes the practical application of the MIMO principle challenging. This workshop addresses both the theoretical background of MIMO techniques, as well as the technical realization of such front-ends and entire systems. Application examples of realized systems and novel prototypes will be presented to illustrate the potential of MIMO radar sensors.

(continued)

Table 1. Workshops for Microwave Week 2014 *(continued)*.

CODE	Title/Instructors
WFG	**Efficient PAs and Transmitters for High Peak-to-Average Power Ratio (PARP) Signals (IMS)** ***Drs. Zoya Popovic and Jose Angel Garcia*** This workshop focuses on approaches to PAs and transmitters for high peak-to-average power ratios (PAPRs) and increasing signal bandwidths. It will address the various approaches that can solve the problem of high-efficiency linear amplification of high PAPR signals: supply modulated PAs (envelope tracking transmitters); advanced Doherty architectures, outphasing/LINC/Chireix transmitters and PAs with second harmonic injection at the output which simultaneously achieve linearity and efficiency. A comparison of the approaches in terms of complexity will be presented, as well as techniques for digital predistortion that are appropriate for linearization of different types of highly-efficient transmitters. The goal of the workshop is to provide high-level instruction in various types of PAs for modern communication and radar signals, beyond a basic introduction and glossary.
WFH	**Terahertz Interconnects (IMS)** ***Drs. Robert W. Jackson and Anh-Vu Pham*** Recent microwave conference publications show increasing interest in integrated Terahertz (THz) devices for applications such as radio astronomy, security, and spectroscopy. This workshop will focus on interconnects, transitions on and off chip, packaged integrated circuits, modules, and on/off chip transmission mediums. Frequencies of interest range from several hundred GHz to a few THz. Topics will include probing in the near-THz, radiating interconnects, nano-interconnects, micromachined interconnects, packaging, and related applications.
WFI	**Recent Advances in Digital Predistortion for Wireless Communications (IMS)** ***Drs. John Wood and Slim Boumaiza*** Digital Predistortion is the pre-eminent technique for linearization of PAs and transmitters in the wireless communications industry. While the basic methodology is well-known and Volterra Series-based implementations are becoming established, several new challenges need to be met as the wireless communications industry demands ever wider bandwidths – over 100 MHz, multiple signal protocols, ultra-fast convergence, and projects in new applications, for instance, microwave point-to-point communications and millimeter-wave access and backhauls. This workshop includes speakers who occupy leading positions in linearization research and development in both industry and academia and will present the state of the art techniques in DPD, as well as address the challenges outlined above.
WFJ	**Inkjet-Printing: A Next-Generation Multi-Layer Packaging Technology for RF and mm-Wave Systems (IMS)** ***Drs. Manos Tentzeris and Benjamin Cook*** Over the last decade, inkjet-printing has progressed from a novel laboratory experiment, to a revolutionary additive fabrication platform with tremendous commercial success due to its low-cost, reel-to-reel, and environmentally friendly nature. Recent advances in inkjet-printing have demonstrated the ability to fabricate multi-layer vertically integrated circuits, sensors, and systems which operate from DC –110 GHz on nearly any substrate including disposable paper and CMOS silicon wafers. This workshop will present inkjet-printing from the ground-up to create an in-depth understanding from the low level of electronic inks and ink formulation and processing techniques to the high level of applications in inkjet-printed RFID and mm-wave components, printed nano material zero-power sensors, and printed active devices.
WFK	**Beyond Graphene Electronic Devices and Their Potential for High-Frequency Applications (IMS)** ***Drs. Dimitris Pavlidis and James Hwang*** This workshop will address Beyond Graphene Electronic Devices and their Potential for High-Frequency Applications by covering a wide range of aspects that range from materials, to devices and their applications. The synthesis of 2D materials by various techniques will be discussed. Emphasis will be placed on high-frequency applications but aspects such as switching, thermal management and integration possibilities with other device types such as sensors and microelectromechanical systems (MEMS) will also be discussed.

course offerings. For further and updated information, you are encouraged to visit the IMS2014 Web site at http://www.ims2014.org/.

We hope that you will find these workshop and short course offerings to be of substantial interest. Given the limited space available for each session, you are encouraged to register early to ensure that a seat is available. Remember that these sessions are designed to be interactive, so come prepared to engage the presenters and your other colleagues in the audience with questions and discussions to gain the greatest value from these sessions. We look forward to meeting you this June in Tampa.

Table 2. Short Courses for IMS2014.

CODE	Title/Instructors
SC1	**Integrated Multi-Technology Physical RF Design Flow** *Mr. Jack D. Sifri* Wireless industry trends towards more functionality in a smaller form factor has driven a continued increase in design density; forcing the combination of multiple technologies into a package or module with increased interconnect density and tighter design proximity. Engineers must design complex multi-chip RF circuits requiring simultaneous design of IC's, laminate, package, and PCB while accurately modeling EM interactions between components, multiple substrates and interconnect. This task is best performed in a simplified integrated design flow developed with this challenge in mind. This short course will feature a comprehensive solution to these challenges. Hands–on lab on Multi-Technology and Nested Technologies will be conducted and will allow participants to build their own RF module (IC and Package) using a fully integrated front-to-back design flow solution. Various examples and demos will be presented and discussed to clearly illustrate these capabilities. During the hands–on lab, participants will learn how to setup a complete module with Multi-Technologies and will create multi-technology substrates, EM setup, and perform EM simulation.
SC2	**Near Field Probes: Useful Tools for RF/MW Engineers** *Dr. Arturo Mediano* Engineers and designers in RF/MW fields are usually interested in EMI topics because they are fully related in their fundamentals, instrumentation and design techniques with the high-frequency design and troubleshooting problems they experience in the lab (EMI) or in production work (EMC). They usually must solve EMI problems in a limited time, under stress and by trial and error because of time and cost limitations of today's development processes. In that process, electric and magnetic near field probes are very useful and valuable tools. With near field probes one can "see" magnetic and electric fields, find EMI sources, evaluate cable layouts, test shielding materials or enclosures, tune circuits in a "non invasive" way, find RF spurs or look for structural or parasitic resonances in components and circuits. The simple ideas, hardware demos and practical examples presented in this short course will be useful for those engineers that cannot be considered EMI/EMC specialists but have a good RF/MW knowledge and interest.
SC3	**Fundamentals of Device Modeling for Nonlinear Circuit Simulation and Microwave Design** *Drs. Jose C. Pedro and David E. Root* Because most undergraduate electrical engineering programs remain focused on linear analysis and design tools, the vast majority of microwave designers still cannot profit from the significant technological advancements that have been made on nonlinear microwave simulation, active device modeling and specific laboratory instrumentation for performance verification. Consequently, they tend to conduct designs relying on experience, heuristic concepts, and trial-and-error iterations in the lab. This Short Course on Fundamentals of Device Modeling for Nonlinear Circuit Simulation and Microwave Design was conceived to bridge this gap. The course starts with the basics of nonlinear systems' responses to various types of stimuli, introducing important concepts such as gain compression, intermodulation and harmonic distortion. Subsequently, the course evolves to present the time-, frequency-and mixed-domains nonlinear circuit analysis and simulation algorithms, explaining fundamental tools such as the harmonic-balance and envelope-following engines. The final part of the course is devoted to the various equivalent-circuit and behavioral modeling tools addressing important model formulations like time-domain transistor compact models and the frequency-domain PHD ("X-parameters") model. To facilitate the comprehension of these concepts, the course will present a practical perspective of computer aided nonlinear microwave design presenting and discussing with the attendees all the steps comprising the design of a PA from the active device model extraction, to the selection of bias and terminations, up to the performance verification.
SC4	**Frequency Synthesizer Design Techniques** *Drs. Lama Dayaratna and Peter White* This short course will present the theory, design, and latest techniques for the design of low noise frequency synthesizers. The objective is to provide a state-of-the-art review of frequency synthesizer design with special reference to low noise techniques. The course is designed to be rigorous where appropriate, while remaining accessible to engineers without a specific background in frequency synthesizer design. The design and development of phase-locked loops and frequency synthesis techniques will be detailed. The laboratory/hands-on portion of the course will provide a state-of-the-art review of frequency synthesizer circuits from a design and development perspective. Participants will have access to hardware and software demonstration 'set-ups' for ease of understanding phase locked loop and frequency synthesizer design concepts. The application of PLLs in RF/microwave systems will also be highlighted by a series of presentations by industry experts. Examples will be given including real-time demonstrations to a variety of problems relevant to the design of frequency synthesizer circuits.