

WORKSHOPS

Monday, 5 June 2017



All Workshops and Short Courses are located at the Hawai'i Convention Center.
Specific room assignments will be provided onsite.



WMA

08:00–17:00

Advanced Microwave Technologies for Internet of Space Applications

Sponsor: IMS

Organizer: Holger Maune, *TU Darmstadt*; Robert Weigel, *FAU Erlangen-Nürnberg*

Abstract: The IEEE Microwave Theory & Techniques Society started an Initiative for the Internet of Space (<https://www.mtt.org/internet-space-initiative-ios>) last year. Also the German VDE published a white paper on the future of satellite communication systems. This workshop will address the new trends set by both initiatives. It is divided mainly into two parts. The first part will give an overview of future satellite systems and the upcoming requirements for microwave engineering. The second part will focus on technologies especially for tunable/reconfigurable transceivers and antennas.

1. IEEE Internet of Space Initiative
Robert Weigel, *FAU Erlangen-Nürnberg*
2. New Concepts for Future Satellite Communications
Volker Ziegler, *Airbus Group*
3. Agile Filter and Transponder Concepts for Small Satellite Transponders
Siegbert Martin, *Tesat Spacecom*
4. Satellite Payload and User Terminal Technologies for Advanced Mobility Applications
Matthias A. Hein, *TU Ilmenau*; Giovanni Del Galdo, *Fraunhofer Institute for Integrated Circuits*; Jens Müller, *TU Ilmenau*
5. Novel Antenna Developments for High Data Rate Small Satellite Communications Networks
Richard Hodges, *Jet Propulsion Laboratory*; Nacer Chahat, *Jet Propulsion Laboratory*; Emmanuel Decrossas, *Jet Propulsion Laboratory*
6. Advanced Silicon-Based Phased-Arrays for SATCOM
Gabriel M. Rebeiz, *UCSD*
7. Programmable RF Filters Based on Hybrid Acoustic-Wave Lumped-Element Resonators
Dimitrios Peroulis, *Purdue University*
8. Frequency Agile Circuits Based on Ferroelectric and MEMS Technology
Fabio Cocchetti, *RF Microtech*; Paola Farinelli, *RF Microtech*; Luca Pelliccia, *RF Microtech*; Roberto Sorrentino, *RF Microtech*
9. Continuously Tunable Liquid Crystal Devices for Space Applications
Matthias Jost, *TU Darmstadt*; Rolf Jakoby, *TU Darmstadt*; Holger Maune, *TU Darmstadt*
10. Multiband, Tunable and Multifunctional Microwave Components Based on Metamaterial Concepts
Ferran Martin, *Universitat Autònoma de Barcelona*; Jordi Bonache, *Universitat Autònoma de Barcelona*; Javier Mata-Contreras, *Universitat Autònoma de Barcelona*

WMB

13:00–17:00

Digital-Intensive Wireless Transmitters for 4G/5G Broadband Mobile Communications

Sponsor: RFIC; IMS

Organizer: Rui Ma, *Mitsubishi Electric Research Labs, Cambridge, MA*; SungWon Chung, *University of Southern California, Los Angeles, CA*

Abstract: Multiband multimode operation and massive multi-input multi-output (MIMO) technology are essential to 4G/5G mobile communications. As an alternative to conventional RF/analog transmitters, all or almost-all digital transmitters are gaining increasing interests since they enable low-cost implementation in a compact form-factor for broadband and flexible operation. Conventionally, the implementations of digital transmitters and digital power amplifiers were mostly limited to silicon based technologies. In recent times, several new attempts using advanced signal processing techniques have been reported, with all-digital high-efficiency power amplifiers in compound semiconductors as well as in silicon. This workshop overviews these recent advancements on digital-intensive wireless transmitter R&D for both base-stations and mobile devices. The focus will be on the digital signal processing techniques and related digital-intensive transmitter circuits and architectures for advanced modulation, linearization, spur cancellation, high efficiency encoding, and parallel processing.

1. Digital Transmitters for the Wireless Infrastructure
Andreas Wentzel, *Ferdinand-Braun-Institute*; Thomas Hoffmann, *Ferdinand-Braun-Institut*; Florian Hühn, *Ferdinand-Braun-Institute*; Wolfgang Heinrich, *Ferdinand-Braun-Institute*
2. Linear and Efficient Digital Transmitters for Future Mobile Communication
Shinichi Hori, *NEC Corporation*; Masaaki Tanio, *NEC Corporation*; Keiichi Motoi, *NEC Corporation*; Kazuaki Kunihiro, *NEC Corporation*
3. Advanced Power Encoding and Non-Contiguous Multi-Band Digital Transmitter Architectures
Rui Ma, *Mitsubishi Electric Research Laboratories*; SungWon Chung, *University of Southern California*; Koon H. Teo, *Mitsubishi Electric Research Laboratories*; Philip Orlik, *Mitsubishi Electric Research Laboratories*
4. All Digital Antenna Array Transmitter for Massive MIMO
Jose Vieira, *University of Aveiro*; Daniel Dinis, *University of Aveiro*
5. Digital Transmitter Architectures for Wireless Handsets – Trends, Opportunities and Challenges
Chih-Ming Hung, *MediaTek*
6. 28 GHz PAs and RF-DAC in UTBB 28 nm FD-SOI CMOS for Massive MIMO Systems
Markus Törmänen, *Lund University*; Johan Wernehag, *Lund University*; Henrik Sjöland, *Lund University*; Andreas Axholt, *Ericsson Research*; Imad Din, *Ericsson Research*; Fenghao Mu, *Ericsson Research*; Henrik Fredriksson, *Ericsson Research*; Martin Anderson, *Ericsson Research*; Stefan Andersson, *Ericsson Research*
7. Capacitive-DAC Based Transmitter Architectures: Modeling and Digital Pre-Processing
Mario Huemer, *Johannes Kepler University*; Stefan Trampitsch, *Intel Corporation*; Jovan Markovic, *DMCE*; Harald Pretl, *DMCE*
8. Encoding Mobile Communication Signals for Switch-Mode Systems
Daniel Markert, *Friedrich-Alexander University Erlangen-Nürnberg*

SUNDAY

MONDAY



WORKSHOPS

Monday, 5 June 2017



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WMC

08:00–17:00

Emerging Applications of THz

Sponsor: IMS

Organizer: Vesna Radisic, *Northrop Grumman Aerospace Systems*; J.-C. Chiao, *University of Texas at Arlington*

Abstract: This workshop will focus on the emerging applications of THz technologies, which has recently exceeded its expectations in terms of achievements, demonstrations and applications. The aspect of what can and cannot be done in this frequency range will be discussed. This workshop will also include RF / microwave applications as well as emerging application in biomedical and environmental fields. We will cover THz imaging and sensing systems and its applications, radiometers for radio astronomy, and measurements techniques. Unexpected applications of THz include single biological cell detection using THz, surface tissue edema mapping using THz imaging, and THz sources and detectors for gas spectroscopy.

1. Impedance Spectroscopy in Biofluids at mm-Wave Frequencies
James Booth, *NIST*
2. Gas Spectroscopy System for Breath Analysis at mm-Wave/THz Using Circuits in SiGe BiCMOS
Klaus Schmalz, *IHP*
3. In situ Surface Tissue Water Content Mapping Using THz Imaging for the Early Detection of Disease and Tissue Viability
Zachary Taylor, *University of California, Los Angeles*
4. THz Radiometers for Remote Sensing of Clouds and Precipitation from Constellations of Small Satellites
Steven Reising, *Colorado State University*
5. Single Biological Cell Detection Using Terahertz and Microwave Radiation
Stephen Hanham, *Imperial College London*; Norbert Klein, *Imperial College London*
6. Plasmonics-Enhanced Terahertz Imaging and Sensing Systems
Mona Jarrahi, *University of California, Los Angeles*
7. A General Review of THz Sensor Applications
Christian Damm, *Technische Universitat Darmstadt*
8. Graphene Plasmonic Metasurfaces as Infrared Optics
Philip W.C. Hon, *Northrop Grumman Corporation*

WMD

13:00–17:00

Flexible Devices, Circuits and Systems Solutions to RF and mmW Front-Ends for 5G Cellular Communications

Sponsor: IMS

Organizer: Eric Kerherve, *University of Bordeaux*; Vincent Knopik, *STMicroelectronics*

Abstract: The continuing growth in demand for high data rate is driving the 5G cellular communications. These communications need to be flexible enough to accommodate all the present and future diverse uses. Available millimeter-wave bands are able to respond to the increasing data traffic, since new technologies and innovative circuit topologies can offer system flexibility. Another critical challenge for the future 5G is the output power over a large frequency range keeping high linearity - to address complex modulation schemes - and low cost requirement. This asks for other complex solution, implementing beam forming networks for instance, with their advantage on spectral flexibility but practical constraint on the front end circuit itself. In this workshop, academic and industry experts will focus on flexible devices, circuits and systems solutions used or imagined in different RF and mmW front-ends, that would pave the way for next 5G cellular communications.

1. Self-Contained Power Amplifier: How to Think Multiple PA Networks for Beam Forming 5G Applications?
Vincent Knopik, *STMicroelectronics*; Boris Moret, *IMS Laboratory*; Eric Kerherve, *University of Bordeaux*
2. Dynamically Changing mm-Wave Circuits for Next Generation mm-wave Systems
Ali Hajimiri, *CALTECH*
3. Circuit and System Architectures for High Data Rate Wireless Backhaul
Sorin Voinigescu, *University of Toronto*
4. Highly Efficient 5G PA Design: Exciting Challenges and Opportunities
Donald Lie, *Texas Tech University*
5. Phased Array Antenna System (PAS) for 5G Cellular Communications
Hiroshi Okazaki, *NTT DOCOMO*
6. Laminate-Based Solutions for 5G and WiFi mmW Antenna Front-Ends
Steve Kovacic, *Skyworks*

WORKSHOPS

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WME

08:00–12:00

Front End Module (FEM) for 5G

Sponsor: IMS; RFIC

Organizer: Roberto Quaglia, *University of Cardiff*; Vittorio Camarchia, *Politecnico di Torino*; Anh-Vu Pham, *University of California, Davis*

Abstract: In this workshop, speakers from leading industries and universities will present state-of-the-art results in the framework of 5th mobile generation (5G) front-end modules (FEMs). Several aspects regarding FEMs will be covered, from the motivations that drive their development to advanced testing. In the first talks, the main trends and challenges for FEMs will be shown from the standpoint of a regulatory body and commercial aspects will be highlighted. Results regarding the design of energy efficient FEMs will be presented considering both compound and silicon technologies, focusing on the pros- and cons- deriving from integration. Integrated solutions for millimetre-wave integrated circuits will be described, carefully evaluating the consequences of increasing centre frequency and bandwidth. Some aspects regarding packaging technologies will be also presented. The important aspect of RX/TX isolation will be also faced, with a description of integrated circulator/isolator solutions based on linear periodic time-varying circuits.

1. The Trends and Challenges of Microwave/Millimeter-Wave in Future 5G Wireless Communication Networks
Maurizio Pagani, *Hawei Technologies Italia*
2. High Efficiency Power Amplifiers and Front-End Module Circuits for 5G Wireless Communications
Anh-Vu Pham, *UC-Davis*
3. Advances in High Performance Cost Effective MMIC and SMD from V to D-Band
Marcus Gavel, *Gotmic AB*
4. RF SOI Technology for PA/FEM Integration
Alexandre Giry, *CEA - LETI*
5. Breaking Lorentz Reciprocity: Non-Reciprocal Integrated Front-End Circulators and Isolators Based on Linear Periodic Time-Varying (LPTV) Circuits
Harish Krishnaswamy, *Columbia University*
6. Wrap-up Remarks and Questions
Roberto Quaglia, *University of Cardiff*; Vittorio Camarchia, *Politecnico di Torino*

WMF

13:00–17:00

High Power WPT

Sponsor: IMS

Organizer: Alessandra Costanzo, *DEI-University of Bologna*; Zoya Popovic, *University of Colorado*

Abstract: High power WPT is a key technology, gaining an increasing interest from many industrial sectors: from automotive, for EV charging “on the move”, to complex distributed industrial plants, located in harsh environments, for simultaneous powering movable parts and sensing and data transfer. The most common operating frequency is in the range of few hundreds of KHz, but now there are emerging solutions in the MHz range, thanks to the device technology evolution. This half-day workshop will present some of the latest results, addressing both theory and system aspects down to the circuit-level perspective, from few watts up to few kilowatts considering the electromagnetic safety issue. Applications for transportation and large industrial plants are presented by the speakers coming from four different continents.

1. A System for Dynamic Inductive Power Supply of Electric Vehicles on the Road
Johannes Russer, *TUM*; Peter Russer, *Institute for Nanoelectronics*
2. Industrial Solutions Using IPT
Grant Covic, *University of Auckland*
3. Electromagnetic Safety of High-Power Wireless Power Transfer System for Transportation
Seungyoung Ahn, *KAIST*
4. High Efficiency Soft Switched Inverters and Rectifiers for Mid Range IPT
Paul Mitcheson, *Imperial College London*
5. Design Considerations for High-Power Large-Gap Capacitive Wireless Power Transfer Systems
Khurram Afridi, *University of Colorado, Boulder*; Zoya Popovic, *University of Colorado, Boulder*
6. Near-Field K-Watt Wireless Power Transfer Controlled by Passive Sensing
Riccardo Trevisan, *IMA Industries*; Alessandra Costanzo, *DEI-University of Bologna*



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WMG

08:00–17:00

New Developments in Microwave Measurements for Planar Circuits and Components

Sponsor: IMS; ARFTG

Organizer: Matthias Ohlrogge, *Fraunhofer IAF*; Uwe Arz, *Physikalisch-Technische Bundesanstalt (PTB)*

Abstract: High-frequency on-wafer measurement techniques are fundamental prerequisites for many applications in science, engineering and metrology. While reliable planar measurements up to millimetre-wave frequencies are becoming more and more state-of-the-art, the traceability in an industrial characterisation process, planar S-parameter measurements of nano-devices and the extension to frequencies beyond 100 GHz are still open topics to the scientific and industrial community. Therefore the aim of this workshop is to provide an overview of these current research areas and to present future directions in the field of planar on-wafer measurements. The first part of this workshop is therefore related to the fundamental question of how to achieve traceability in planar on-wafer measurements. More specifically, this means we will discuss the characterization and verification process of different error mechanisms in a planar on-wafer environment. The second part of the workshop is linked to the measurement of nano-electronic devices. Since these components are rapidly finding their way into the field of millimetre and sub-millimetre wave frequencies, we are facing even more the difficulty of how to perform reliable RF measurements on such devices. This includes issues such as the impedance mismatch problem or the challenge of probing at nanoscale dimensions. Besides the complexity regarding the measurement of nano-devices, reliable on wafer measurements at sub-millimetre frequencies are nowadays getting increasingly important. At these high frequencies one faces the problem of crosstalk phenomena and excitation of higher order modes. These relevant topics together with future thoughts on how to solve them shall be covered in the third part of this workshop. To summarize the workshop and get a broad feedback on potential future topics we will initiate a round table discussion at the end. At this point everybody will have the opportunity to interact with the speakers more closely than in the short discussions after each talk.

1. PlanarCal - A European Project on Planar S-Parameter Measurements
Uwe Arz, *Physikalisch-Technische Bundesanstalt*
2. Traceability for Large-Signal On-Wafer Measurements
Dylan F. Williams, *NIST*
3. On-Wafer Measurements with VNA Tools II
Johannes Hoffmann, *Eidgenössisches Institut für Metrologie METAS*; Michael Wollensack, *Eidgenössisches Institut für Metrologie METAS*; Juerg Ruefenacht, *Eidgenössisches Institut für Metrologie METAS*
4. Precision and Reproducible On-Wafer Measurement at Millimeter-Wave and THz Frequency
Masahiro Horibe, *National Metrology Institute of Japan*
5. Wafer-Level Calibration, Measurement and Measurement Uncertainties at the mm-Wave Frequency Range
Andrej Rumiantsev, *MPI Corporation*
6. On-Wafer Characterization of Nano-electronic Devices and Nanomaterials
Mitch Wallis, *NIST*; Pavel Kabos, *NIST*
7. Near-Field Scanning Millimeter-Wave Microscope Combined With a Scanning Electron Microscope
Kamel Haddadi, *Institut d'Electronique de Microélectronique et de Nanotechnologie*
8. Benefits and Obstacles of Planar On-Wafer Measurements at Submillimeter Frequencies
Matthias Ohlrogge, *Fraunhofer IAF*
9. Design, Characterization and Evaluation of TRL Calibration Kits Integrated Using Silicon Based Technologies
Marco Spirito, *Delft University of Technology*
10. Modeling Conductor Surface Roughness
Gerald Gold, *Friedrich-Alexander University Erlangen-Nürnberg*

WMH

08:00–12:00

Non-Doherty Load-Modulated PAs

Sponsor: IMS

Organizer: Steve Cripps, *Cardiff University*; Zoya Popovic, *University of Colorado Boulder*

Abstract: This workshop focuses on approaches to efficient power amplifier (PA) design for applications where the signal has a high peak to average power ratio (PAPR). While the Doherty amplifier has been predominant in cell-phone base stations, other approaches where the transistors are load-modulated have recently gained attention but are not always well understood. These include outphasing (Chireix) PAs, architectures with varactor diodes in the PA output, broadband load modulation in actively-controlled balanced amplifiers, as well as both digital and analog load modulation combined with supply modulation. The selected speakers are well-established internationally in the field of power amplifiers and transmitters. The speaker list includes researchers from industry, academia and private consultants. Several of the speakers are pioneers in the field of microwave power amplifiers, and authors of highly cited papers and a well-respected textbook. The goal of the workshop is to provide high-level instruction in various types of PAs with load modulation, other than the well-known Doherty architecture, and beyond a basic introduction and glossary.

1. Modern Outphasing: Potential and Pitfalls
Taylor Barton, *University of Colorado, Boulder*
2. Modulation and Filtering Techniques for Pulsed Load Modulated (PLM) PAs
Ethan Wang, *UCLA*
3. The Load Modulated Balanced Amplifier (LMBA)
Daniel Sheppard, *Cardiff University*; Steve Cripps, *Cardiff University*
4. A Novel Load Modulated Envelope Tracking PA Technique
Morten Olavsbraaten, *Norwegian University of Science and Technology*
5. Efficient and Linear RF Power Amplification Using Varactor-Based Dynamic Load Modulation
Christian Fager, *Chalmers University*
6. Unfazing the Outphasing RFLPA Circuit
Steve Cripps, *Cardiff University*
7. Measurements of Load Modulation in Outphasing PAs with Supply Modulation
Zoya Popovic, *University of Colorado, Boulder*; Michael Litchfield, *BAE Systems*



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WMI

08:00–17:00

Novel 5G Applications of Nonlinear Vector Network Analyzer for Broadband Modulation and Millimeter Wave Characterization

Sponsor: IMS; ARFTG

Organizer: Patrick Roblin, *The Ohio State University*;
Apolinar Reynoso-Hernandez, *CICESE*

Abstract: The world's thirst for communication keeps on increasing as users are attracted to new broadband services for accessing data on the cloud, video-conferencing, and streaming videos using various user equipment. This growing demand for higher data rates (≥ 6 Gbps) is motivating vigorous research activities worldwide on the development of wideband and multiband systems above and below 6 GHz. The fifth generation (5G) of wireless standards are being developed for cellular communication by 3GPP to directly address these issues. This workshop will focus on new 5G applications of nonlinear vector network analyzers (NVNAs) including: (1) Vector signal analysis for measuring with a high dynamic range, modulated signals with very large bandwidth (multiple GHz). (2) The characterization of millimeter transistors which includes the impact of large-signal cyclo-stationary memory effects in CW mm-wave small-signal response. (3) Newly supportive phase references and phase-calibration techniques for NVNAs permitting the full characterization of RF PAs under various wideband and multiband excitations. With the development of these novel measurement techniques, new challenges in behavioral & circuit modeling of devices for broadband modulated multi-harmonic excitations must also be addressed. This includes characterizing and modeling the mutual coupling between the elements of the massive MIMO active antenna array and the associated dynamic load modulation it induces. Also the mixed-signal instrumentation and measurement approaches needed to characterize software defined radio and digital radio front ends for the new 5G communication paradigm will be presented together with the application of D-parameters to mixed-signal integrated solutions for 5G. This workshop will bring together some of the leading world experts in the field to present both these novel measurement techniques and associated emerging behavioral modeling techniques.

1. NVNA for Accurate DUT Measurements With Wideband Repetitive Modulated Signals
Jean-Pierre Teyssier, *Keysight Technologies*
2. Dynamic-Bias Measurements for Microwave and mm-Wave Transistor Characterization: A Step Further
Dominique Schreurs, *K.U. Leuven*; Gustavo Avolio, *K.U. Leuven*; Antonio Raffo, *University of Ferrara*
3. Millimeter-Wave Multi-GHz-IF Receivers: Linearity and Correction Considerations
Jon Martens, *Anritsu*
4. Dense-Spectral-Grid Multi-Band NVNA Measurement for Characterizing RF PA Inter-Modulation and Harmonic Nonlinearities
Yichi Zhang, *National Institute of Metrology*
5. Review of Broadband Behavioral Modeling and Linearization Techniques for 5G
Patrick Roblin, *The Ohio State University*; Meenakshi Rawat, *ITT Roorkee*
6. Robust Digital Predistortion Method Based on Dynamic X-Parameters
Jan Verspecht, *Keysight Technologies*
7. Challenges for Nonlinear Memory Characterization and Modeling in Broadband PA Applications
Edouard Ngoya, *XLIM, University of Limoges*; Damien Gapillout, *XLIM, University of Limoges*; Sebastien Mons, *XLIM, University of Limoges*
8. NVNA Measurements for 5G Active Antenna Array Behavioral Modeling
José Carlos Pedro, *Universidade de Aveiro*; Filipe Barradas, *Universidade de Aveiro*; Telmo Cunha, *Universidade de Aveiro*
9. Enabling 5G Digital Communications Using D-Parameters
Nuno Borges Carvalho, *Universidade de Aveiro*

WMJ

08:00–17:00

PAs for 5G Mobile Communication: Technologies and Challenges

Sponsor: IMS

Organizer: Kamal Samanta, *Sony Europe, UK*; Rüdiger Quay, *Fraunhofer Institute for Applied Solid State Physics*

Abstract: Ever rising demand of high data-traffic expects significant deployment of 5G cellular systems in 2020. 5G communication system demands high data rate, up to 10 Gbps, RF or hybrid beamforming, high device density for IOT and very dense base-station deployment. These unprecedented demands require new-generation power amplifiers (PAs) operating at millimetre-wave bands and delivering high linear power with wide-bandwidth and high efficiency yet with highly reduced size and cost. Therefore, broadband linear PAs with high efficiency at high PAPR, supporting higher order modulation, is one of the most critical components for a 5G mobile and backhaul system. This requires a novel solution in semiconductor (SC)/device technology in combination with innovative circuit topologies and integration techniques. Si devices are very attractive due to high maturity, complex digital and multifunction capability at a low cost. Whereas III/V compound semiconductors (GaAs, GaN & InP) provide higher power, bandwidth and efficiency. Recently there are enormous advancement in Si/SiGe and III/V PAs, including those on SOI for addressing the high performance and cost simultaneously. This very timely workshop will incorporate a wide range of presentations highlighting the recent trends and the state-of the art developments in semiconductor/device technologies as well as circuit and system design and integration techniques for 5G PAs, including those for Ka band handsets as well as Ka, E, and W bands infrastructure. Workshop will present the latest result and compare performance of novel PAs and PA intensive sub-systems, like RF beamformer, for various circuit and device technologies, and in terms of BW, ACLR, efficiency with high PAPR, and cost. This will include PAs using CMOS/BiCMOS (on Si and SOI), SiGe, GaN (on SOI and SiC) and GaAs. Further, will present PAs with circuit topologies including Doherty, outphasing, stacked and envelope-tracking for enhanced performance at back-off power, for fulfilling challenging requirements for 5G deployment.

1. GaN/Si MMICs for 5G Mobile Telecommunications
Marc Rocchi, *OMMIC*
2. Efficient RF to mm-Wave Power Amplifiers Based on SiGe and CMOS SOI Technologies
Saeed Mohammadi, *Purdue University*
3. 5G PA Implementation and Integration Aspects
Kamal Samanta, *Sony Europe*; Chris Clifton, *Sony Europe*
4. High-Efficiency CMOS/BiCMOS PAs for Complex Waveforms at Microwave and Millimeter-Wave Bands
Jim Buckwalter, *University of California, Santa Barbara*
5. Advanced GaAs Integration for 5G Mobile Communications
David Danzilio, *WIN Semiconductor Foundry*
6. GaN PAs and Modules for 5G Infrastructure and Backhaul to mm-Wave Frequencies
Rüdiger Quay, *Fraunhofer Institute for Applied Solid State Physics*
7. Doherty and Outphasing Power Amplifiers for 5G Systems
Mustafa Özen, *Chalmers University of Technology*
GaN/CMOS Integration for Active Array Antennae Systems
Peter Singerl, *Infineon Technology*
8. Power Amplifier Requirements for mm-Wave 5G Systems
Bror W. Peterson, *Qorvo*



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WMK

08:00–17:00

RF and Optical Techniques for Non-Contact and Wearable Health Monitoring

Sponsor: IMS

Organizer: Aly Fathy, *University of Tennessee*; Changzhi Li, *Texas Tech*

Abstract: In recent few years, both the industry and academia are working diligently in making non-contact and wearable devices for assessments of health condition such as cardiovascular function an in-expensive practice in daily life. Among all the possible solutions, optical and radio frequency techniques have shown great promise because of their prevalence in day-to-day routine and compatibility with many consumer electronic devices. Cameras, WiFi devices, and plug-in radar devices are among the most popular solutions. This workshop presents some of the recent developments on optical and radio frequency technologies for non-contact and wearable monitoring of health information such as respiration and heartbeat. The technologies presented operate in a broad frequency range from a few hundreds of MHz to optical spectrum, with operation range from a few meters to direct-contact detection. Special emphasis of this workshop is dedicated to solutions at both the circuit and system levels. High sensitivity, low cost, and ease of integration with existing consumer electronics such as smart phones are some of the distinguished features of the presented technologies. A panel discussion will provide valuable comparison among different non-invasive health monitoring solutions and guide the audience toward the future of commercial development and scientific research.

1. Comparison of UWB Doppler Radar and Camera Based Photoplethysmography in Non-Contact Multiple Heartbeats Detection
Lingyun Ren; *University of Tennessee*; Farnaz Foroughian; *University of Tennessee*; Sabikun Nahar; *University of Tennessee*; Aly Fathy; *University of Tennessee*
2. A Robust Non-Contact Vital Signs Monitoring Using a Camera
Ashok Veeraraghavan, *Rice University*
3. Arrhythmia Discrimination Using a Smartphone
Jo Woon Chong, *Texas Tech University*
4. An Advanced Self-Injection-Locked Radar for Monitoring Vital Signs with Reduced Body Motion Artifacts
Tzyy-Sheng Horng, *National Sun Yat-Sen University*
5. Non-Contact Non-Invasive Monitoring of Small Laboratory Animal's Vital Sign Activities Using a 60-GHz Radar
Tien-Yu Huang, *University of Florida*; Jenshan Lin, *University of Florida*
6. Wireless Wearable Physiological Sensors
Victor Lubecke, *University of Hawaii*; Olga Lubecke, *University of Hawaii*
7. Wearable Radar Sensors for Indoor Tracking and Health Monitoring
Changzhi Li, *Texas Tech University*, *University of Alcalá*; Roberto García, *University of Alcalá*; Jose Munoz, *University of Alcalá*
8. Medical Device Product Trends: Size, Wireless, and Technology
Eric Chow, *LivaNova Neuromodulation Unit*
9. Research on Key Techniques of The Non-Contact Detection of Physiological Signals Based on Imaging Photoplethysmography
Yuejin Zhao, *Beijing Institute of Technology*

WML

08:00–12:00

RF to/from Bits: Challenges in High Frequency Mixed Signal Measurements and Design

Sponsor: IMS

Organizer: Jon Martens, *Anritsu*; Nuno Carvalho, *IT-Universidade de Aveiro*

Abstract: With higher levels of integration and ever higher bandwidth requirements in communications, telemetry and control systems, mixed signal measurements and behaviors in these systems involving data converters are increasingly important. Receiver chains must manage wide bandwidths and not introduce added distortions through data conversion, predistorters must correctly digitize and process transmitter behaviors at sufficient speed with a minimum of added transfer errors, and digital transmitters must control detailed spectral purity requirements. Characterization of systems like these must handle a mixed-domain calibration space and detail a complicated multivariate problem where converter clocks can play an even greater role than do front end local oscillators. This workshop will cover this category from a number of viewpoints to highlight some approaches to distortion management/characterization, managing details of converter behavior and better understanding performance of these complex systems.

1. Challenges in Characterization of Mixed Signal Systems
Jon Martens, *Anritsu*
2. How Not to Mess-Up the Bits When Converting Them to and From Microwave Signals
Justin Magers, *National Instruments*
3. Mixed-Signal Characterization Approaches for 5G Software Defined Radio Design
Nuno Carvalho, *IT-Universidade de Aveiro*
4. System-Level Design Considerations for Digital Predistortion of Wireless Base Station Transmitters
John Wood, *Obsidian Microwave*
5. Modeling RF Complex Circuits for Accurate System Simulation
Damien Gapillout, *AMCAD Engineering*; Christophe Mazière, *AMCAD Engineering*

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WMM

08:00–17:00

Silicon Technologies for mmWave Applications

Sponsor: IMS; RFIC

Organizer: David Haramé, *GLOBALFOUNDRIES*; Ned Cahoon, *GLOBALFOUNDRIES*; Baljit Chandhoke, *GLOBALFOUNDRIES*; Anirban Bandyopadhyay, *GLOBALFOUNDRIES*

Abstract: Silicon technologies have made great strides and are now mainstream for most mmWave applications. They are pervasive in all but the higher power applications. The breadth of silicon technologies includes bulk RF CMOS, SiGe BiCMOS, Partially-Depleted (PD) RF SOI, and Fully-Depleted (FD) SOI. However, the market opportunity for silicon mmWave technologies has until recently been primarily relegated to lower volume wireless infrastructure and optical networking applications. With the push towards 5G standards at 28 GHz and above, broadband WTTx (Wireless-fiber-To-The-X) at 28 GHz, broadband satellite communications at Ku and Ka band, wireless backhaul at 60 GHz, licensed E-band at 71-76 GHz and 81-86 GHz, vehicular radar at 77 GHz, and photonics, many large volume opportunities have arrived. Designers are interested in understanding: 1) the current status of silicon technologies for mmWave, 2) innovations in models, design kits (DKs) and simulation/design tools, and 3) R&D and the transistor technology roadmap for the future. Designers need to know the impact of these technology developments on the performance and cost of mmWave circuits and systems. This workshop will explore these questions in detail. Our invited speakers will present a technology and argue for its merits against other technology choices given its status, roadmap, R&D, maturity and cost. Each section will include presentations on the technology, models, circuits and systems. After a brief introduction the workshop will have three sections: RFCMOS, SiGe BiCMOS, and RFSOI (PDSOI and FDSOI). Topics will include the following: analog versus digital, SOC with low power logic and integrated RF, partitioned systems with higher performance and more mature RF technologies, and low-cost bulk CMOS versus SOI and SiGe. The workshop will conclude with a panel of the technologists. Each panel member will advance their position and answer the question: "Has RF performance peaked in silicon technology?"

1. An Overview of Silicon Technologies for mmWave Applications
Lawrence Larson, *Brown University*
2. Silicon Technologies for mmWave Application: RF CMOS Technology
Peter Baumgartner, *Intel*
3. RF CMOS Modelling
Christian Enz, *EPFL Switzerland*
4. No Waves, No Glory: The Renewal of RF CMOS for 5G mm-Wave Applications
Michael Reiha, *Nokia Networks*
5. High Performance SiGe HBT BiCMOS Technology
Holger Rucker, *IHP*
6. High-Performance SiGe BiCMOS for Millimeter-Wave Applications
Alvin Joseph, *GLOBALFOUNDRIES*
7. Compact SiGe HBT Modeling for mm- and Sub-mm-Wave Applications
Michael Schroeter, *Technical University of Dresden*
8. RF and Wideband Circuit Benchmarks in SiGe-BiCMOS
John Long, *University of Waterloo*
9. Millimeter-Wave Circuit and System Capabilities and Trade-offs for SiGe BiCMOS
Brian Floyd, *North Carolina State University*
10. RF PDSOI and FDSOI Technology: Silicon Technologies for mmWave Applications
David Haramé, *GLOBALFOUNDRIES*
11. Modeling PDSOI for mmWave RF Applications
Josef Watts, *GLOBALFOUNDRIES*; Jean Charles Barbee, *LETI*
12. mm-Wave and Broadband Design in FD-SOI CMOS Technologies
Sorin Voinigescu, *University of Toronto*
13. mmWave Transceiver Design in SOI CMOS
Alberto Valdes-Garcia, *IBM*
14. Panel: Has RF Performance Peaked? Are the Glory Days Behind Us?
Larry Larson, *Brown University*

WMN

08:00–17:00

System Requirements and Technologies for Tunable Filters

Sponsor: IMS

Organizer: Raafat Mansour, *Waterloo University*; Xun Gong, *South Florida University*; Pierre Blondy, *Xlim - CNRS - Université De Liroges*

Abstract: Tunable RF and microwave filters are critical components in reconfigurable radios, radars and sensors. Over the past several years, a number of different technologies have been proposed to address this challenge with distinct advantages, drawbacks, maturity levels and market potentials. This workshop will review the state of the art in several of these technologies. The performance, requirements and market opportunities for tunable filters used in wireless systems will be discussed for both mobile applications (FBAR) and base station applications (high-Q filters). Speakers will address technologies such as ferroelectric BST, MEMS, Phase Change Materials (PCM) and active N-Path in the realization of tunable filters. Novel concepts for tunable fluidic filters, integrated reconfigurable filter/antennas and micro-machined filters will also be presented. Discussion of the opportunities presented by each technology will be included in relation to their relevant application space.

1. Prospects for Front-End Modules Employing Reconfigurable Filters
David A. Feld, *Broadcom*
2. Radio Frequency Tunable Filters: What are Possible and What are NOT?
Ken-ya Hashimoto, *Chiba University*
3. CMOS N-Path Filters Tunable by a Digital Multi-Phase Clock
Eric Klumperink, *Twente University*
4. Advances in Tunable Networks Using RF MEMS
Gabriel Rebeiz, *UCSD*
5. Switchable and Tunable Ferroelectric Devices for Adaptive and Reconfigurable RF Circuits
Amir Mortazawi, *University of Michigan*
6. Tunable and Fixed Filtering Solutions for Enhancing Dynamic Range and Flexibility of 4G-LTE Systems
Rafi Hershtig, *K&L Microwave - Pole Zero*
7. Fully Reconfigurable Bandpass and Bandstop Filters
Dimitrios Peroulis, *Purdue University*
8. Fluidic Microwave Reconfigurable and Tunable Circuits
Kamran Entesari, *Texas A&M University*
9. Reconfigurable Filter/Antenna Systems
Xun Gong, *University of South Florida*
10. Use of MEMS and PCM-Based Switches in the Design of High-Q Tunable Filters
Raafat Mansour, *Waterloo University*



WORKSHOPS

Monday, 5 June 2017



All Workshops and Short Courses are located at the Hawai'i Convention Center.
Specific room assignments will be provided onsite.

WMO

08:00–17:00

Technologies for 5G Backhaul and Infrastructures

Sponsor: IMS

Organizer: Telesphor Kamgaing, *Intel Corporation*; Vittorio Camarchia, *Politecnico di Torino*; Alberto Valdes-Garcia, *IBM*

Abstract: The next generation mobile communication standard (5G) is considered by many as a major advancement that will address a wide range of applications beyond personal mobile data access such internet of things (IoT) to vehicle to vehicle communications (V2V). The expected high demand in data traffic emanating from those emerging applications and the strong desire for immersive experiences, pose new challenges for the backhaul and networking infrastructure. Both sub-6 GHz and millimeter wave radio access technologies are widely mentioned as candidate solutions that will enable cell-to-cell or backhaul-to-infrastructure communication. This workshop brings together researchers from the academia and the industry to discuss both challenges and some recent advances in the area of the backhaul & mobile infrastructure. Each presenter will cover one or multiple aspects of the following topics: (1) Massive MIMOs and distributed/reconfigurable networks; (2) Power amplifiers and power efficient transceivers; (3) Applications of III-V technologies in base stations and backhaul infrastructure; (4) Transceivers for backhaul infrastructure; (5) Test and measurement challenges; (6) Coding and modulation schemes for high spectral efficiencies in the wireless backhaul of mobile access networks.

1. Millimeter Wave Distribution Network and Architecture Using Modular Antenna Arrays
Ali Sadri, *Intel Corporation*
2. Silicon Enabled AESAs for 5G Backhaul and Infrastructure
Nitin Jain, *Anokiwave, Inc.*; David Coman, *Anokiwave, Inc.*
3. MMIC Design for 5G Backhaul and Infrastructures: Challenges and Solutions
Maurizio Pagani, *Huawei Technologies*
4. Coding and Modulation Schemes for High Spectral Efficiencies in the Wireless Backhaul of Mobile Access Networks
Cesare Salvaneschi, *Siae Microelettronica S.p.A.*
5. Circuits and System Solutions for the V, E and D-band Backhaul Using III-V Technologies
Goran Granstrom, *Gotmic AB*
6. Towards 5G: Power Amplifiers in Wireless Backhaul
Vittorio Camarchio, *Politecnico di Torino*; Roberto Quaglia, *Cardiff University*; Marco Pirola, *Politecnico di Torino*
7. Silicon-Based Transceiver Chipsets for 60 GHz and E-band P2P Links
Danny Elad, *On Semi*
8. Modular BiCMOS 60-GHz Beamforming Solution for Scalable 5G Backhaul Networks
Minsu Ko, *IHP*; Dietmar Kissinger, *IHP Germany and Technical University Berlin*; Andrea Malignaggi, *IHP*; Jesus Gutierrez Teran, *IHP*; Ahmet Cagri Ulusoy, *Michigan State University*

SHORT COURSES

Monday, 5 June 2017



All Workshops and Short Courses are located at the Hawai'i Convention Center.
Specific room assignments will be provided onsite.

SMA

08:00–17:00

Coupling-Matrix-Based Design of RF/Microwave Filters

Sponsor: IMS

Organizer: Dimitrios Peroulis, *Purdue University*; Roberto Gomez-Garcia, *University of Alcalá*; Dimitra Psychogiou, *University of Colorado Boulder*

Abstract: This short course introduces students to the science and art of RF/microwave filter design. Students taking this course should be familiar with fundamental RF concepts, such as impedance matching, transmission line theory, and scattering parameters. Previous exposure to filter design is helpful but not required. The course starts by introducing students to the importance of RF filters in current high-frequency applications followed by the fundamentals of filter design. It subsequently introduces students to the coupling-matrix-based design theory followed by many practical synthesis examples. Without sacrificing mathematical rigor, the course emphasizes the practical step-by-step design process. Relevant Matlab™ scripts will be also provided to students as a guideline so they can perform their own designs. Students will be able to design complex transfer-function filters (e.g., multi-band, filter cascades) that go beyond traditional textbook-style filter examples. In addition, several planar and three dimensional filter developments will be presented as supporting practical examples. The course will conclude by providing examples of the most successful reconfigurable filter architectures that exploit the aforementioned techniques to realize adaptive-transfer-function filters. Students completing this course will be able to understand basic and advanced filter concepts as well as comprehend state-of-the-art designs published in the recent technical literature.

SMC

08:00–17:00

SOI, From Basics to Applications

Sponsor: IMS

Organizer: Mostafa Emam, *Incize*

Abstract: The Silicon-on-Insulator (SOI) technology is gaining more grounds in the domains of low power and RF applications. Nearly 100% of RF antenna switches in wireless system Front-End Modules (FEM) are based on SOI. A FEM entirely built on SOI can be implemented in the observable future as both academia and industry are working in this direction. In addition, FDSOI opens new horizons for designers by offering more flexibility for design and optimisation of low power applications. This short course will be of interest for engineers and graduate students willing to prepare themselves for the future of low power and RF applications.

SMB

08:00–17:00

Fundamentals of Microwave Imaging

Sponsor: IMS

Organizer: Abbas Omar, *University of Magdeburg*

Abstract: In this short course the fundamentals of microwave imaging are presented. We will begin with the simple equations describing transmission-line wave propagation that are known to almost all electrical engineers. Based on the relations between intrinsic impedance, local reflection coefficient and local input impedance, and propagation speed, a nonlinear Riccati-type differential equation is derived, which represents the fundamental equation of one-dimensional imaging. Exact and different approximations of this equation in both “direct” and “inverse” cases are presented and discussed. The discussions show in a very clear, intuitive, and systematic way which conceptual and practical problems characterize the imaging process. These include the resolution degradation due to bandwidth limitations, the creation of what is called “artifacts” in imaging due to improper image reconstructions, as well as noise impact on imaging quality. The course moves then smoothly to two- and three-dimensional imaging schemes explaining the concept of “temporal” and “spatial” focusing and the role of antenna arrays for achieving the latter. The tradeoff between wave penetrability (usually associated with low frequencies) and resolution needs (dictating bandwidth requirements) is discussed. A number of imaging modalities and their technical, medical, environmental, and industrial applications are finally presented.

MONDAY