## WMA 08:00-17:00

**Millimeter-Wave Power Amplifier Technology: Where are We and Where are We Headed?**
Sponsor: IMS

**Organizer:** Allen Katz, *The College of New Jersey/Linearizer Technology, Inc,* James Schellenberg, *QuinStar Technology, Inc.*

**Abstract:** At frequencies below 100 GHz, GaN technology continues to dominate power applications, with single-chip power levels of 20 W at Ka-band and 2 W at 100 GHz. Silicon continues to make advances in both power and frequency, particularly for high volume, commercial applications. Above 100 GHz, InP technology (both HEMT and HBT) dominate, and for high power (>100 W), thermionic devices (tubes) are still the technology of choice. This workshop brings together, experts representing these millimeter-wave (mmW) power technologies to discuss where mmW power is today and where it is headed. Clearly, GaN dominates the power spectrum up to 100 GHz. Questions to be addressed: What are the limits of GaN in power and frequency? While InP has made great strides at higher mmW and THz frequencies, what are its power and frequency limits and will it compete with GaN? What is the status of Si power technology and will it dominate all high-volume commercial applications? What is the future role for thermionic devices at mmW?

1. Future Satellite Communications Opportunities at V & W Bands
   Michael Chang; *Aerospace Corporation*
2. Wideband GaN HEMT Power Amplifiers at K/Ka-Band and E-Band
   James Komiak; *BAE Systems*
3. GaN mm-Wave Power Amplifier MMIC Design and Status
   Charles Campbell; *QORVO, Inc.*
4. Advances in Si-Based Mm-Wave Power Amplifiers
   Peter Asbeck; *University of California at San Diego*
5. Submillimeter Wave Power Amplification with InP HEMT
   William Deal; *Northrop Grumman Space Technology*
6. InP HBTs for high-power 70 to 500 GHz amplification: its status today and where it is going
   Zach Griffith; *Teledyne Scientific Company*
7. Making the Link: Millimeter Wave Applications and High Performance RF Vacuum Electronics
   Carter Armstrong; *L-3 Communications*
8. Millimeter-wave GaN Power Amplifiers using High-Efficiency Power Combining
   Edward Watkins; *QuinStar Technology, Inc.*
9. Power Amplifier Linearization at Millimeter-Waves
   Allen Katz; *The College of New Jersey/Linearizer Technology, Inc.*

## WMB 08:00-12:00

**Advances in High-Power SSPA Technology for KW-Operation at Microwave Frequencies**
Sponsor: IMS

**Organizer:** Frank Sullivan, *Raytheon Company,* Kamal Samantha, *Milmega,* Ruediger Quay, *Fraunhofer Institute Applied Solid-State Physics*

**Abstract:** The tremendous advances in high-voltage ldmos technologies and gallium nitride HEMT technologies have led to the availability of compact solid-state-devices and -modules for the generation of kilowatts of RF-output power at microwave frequencies in an efficient fashion. The two technologies have driven the start-of-the-art of microwave power generation to support applications such as radar, advanced macro-base stations for mobile communication, and broadcasting. These applications present major challenges beyond the abilities of classical si-bipolar technology. There is further a continuous demand for higher power levels at high efficiencies to reduce the transistor space to a minimum driving the development. The workshop will address the specific needs and techniques to deal with high-power microwave generation, such as low-impedance design, pre-matching, thermal management for pulsed- and cw-operation, high-power characterization by load pull and others, efficient power combining, and module and system integration including linearization. Application examples will be given. These aspects include the architecture and associated technology, RF stability issues, the manufacturing issues, the required advanced packaging, reliability and cost. All the aspects will be tagged with particular focus on the needs of the new advances in the various frequency ranges. Six excellent speakers from global main drivers from academia, research, and industry are dedicated to the very aspects of kw-power operation. The WS focuses on semiconductor advances for high-voltage RF technology for ldmos and Gan, design aspects, also for broadband operation, packaging and module aspects, power combining techniques, high-power characterization including load pull, and circuit design techniques. This technology has advanced considerably in the last 5 years and this workshop aims to highlight these advancements and prospects for critical areas and show what needs to be achieved going forward.

1. Recent advances, technology comparison, and system requirements for kW-level pulsed RF power transistors
   Dr. John Walker; *Integra Technologies Inc.*
2. High voltage LDMOS technologies for kW generation
   Roger Williams; *Ampleon*
3. Advanced Broadband GaN Power Amplifiers with kW CW Power
   Kamal Samantha; *Milmega*
4. 800W 3way DPA at 2.1GHz-2.2GHz (90MHz SBW) in T3PAC
   Jin Shao; *Infineon Technologies AG*
5. Linearization for kW plus Power Amplifiers
   Katz Allen; *Linearizer Technologies*
6. Methods and Limitations To Achieving Multi-Kw Power Levels Using Spatial Combining Techniques In Conjunction With GaN Semiconductor Technology
   Scott Behan; *QORVO, Inc.*

## WMC 13:00-17:00

**Power and Signal Integrity Characterization Techniques**
Sponsor: IMS; ARFTG

**Organizer:** Heidi Barnes, *Keysight Technologies*, Ken Wong, *Keysight Technologies,* Mike Resso, *Keysight Technologies*

**Abstract:** Many technology companies must design and develop highly complex chips, packages, and boards for telecom and datacom applications. Issues of power and signal integrity arise from a steady increase in IC speed and data transmission rates combined with a steady decrease in power-supply voltages. The latest applications from cloud computing to the Internet of Things force these new designs into smaller geometries and with higher densities. The integration of numerous I/O counts, multiple stacked chips and packages, and higher electrical performance requirements go far beyond simple schematic netlists to determine performance. Modern electro-magnetic simulations and RF/uW measurement techniques are increasingly being applied to these complex 3D distributed systems. Breakthrough solutions based on intuitive understanding of fundamental power integrity and signal integrity characterization techniques can help the design engineer overcome these challenges. This workshop will present multiple perspectives from experts in the field starting with theoretical fundamentals through practical real world design case studies.

1. I Know Signal Integrity, I Have Heard of Power Integrity, but What is SI/PI Co-Simulation?
   Heidi Barnes; *Keysight Technologies*
2. The Bandini Mountain, a pathological problem in PDN Design
   Eric Bogatin; *University of Colorado*
3. Power Integrity Challenges in the Race for Small Size and High Efficiency Power Delivery
   Steven Sandler; *PicoTest*
4. Today's Power Integrity Issues with FPGA Applications
   Jack Carrel; *Xilinx, Inc.*

## WMD 08:00-17:00

**Radio Miniaturization, Terahertz Nano-Sized Radios and Potential Applications**
Sponsor: IMS; RFIC

**Organizer:** Hua Wang, *Georgia Institute of Technology,* Joe Qiu, *US Department of Defense (DoD)*

**Abstract:** Integrated radios are indispensable for wireless sensor networks, Internet-of-Things (IoT) devices, implantable/prosthetic devices, autonomous micro robots, tracking and remote control of cybernetic insects, and chip-to-chip links, etc. In many of these applications, it is essential to reduce the radio dimension as much as possible. Past efforts in miniaturized radios have targeted systems operating at microwave frequencies, and their system sizes are largely limited by the antennas. Recent developments in integrated circuit (IC) technologies have enabled chip-scale THz circuits and systems. For example, the cutoff frequency of state-of-the-art CMOS processes is approximately 500 GHz and expected to approach 1 THz by 2018. Chip-scale THz sources and phased-arrays with integrated antennas based on CMOS have been demonstrated at 500 GHz and will surely be pushed to even higher frequencies. The resulting THz Radio systems thus can dramatically reduce the circuit chip and antenna size. This workshop will review recent developments in radio miniaturization. It will discuss device technologies, circuit innovations, and integrated systems for aggressive radio miniaturization at THz. It will also explore the applications of such THz nano-sized radios.

1. Circuit design challenges for terahertz emerging applications in silicon technologies
   Frank Chang; *University of California, Los Angeles*; Richard Hadi; *University of California, Los Angeles*; Yan Zhao; *University of California, Los Angeles*
2. Energy Efficiency of CMOS Terahertz Electronics
   Kenneth O; *University of Texas at Dallas*; Wooyeol Choi; *University of Texas at Dallas*
3. Ultra-Miniaturized Low-Power THz Transceiver System in Silicon
   Hua Wang; *Georgia Institute of Technology*
4. Terahertz: The Last Untapped Spectrum
   Ehsan Afshari; *Cornell University*
5. High-power, broadband Multipliers for high-speed microscale radios
   David Ricketts; *North Carolina State University*
6. Insect-based wireless networks – challenges and opportunities
   Amit Lal; *Cornell University*
7. Future challenges for radio miniaturization in Speckled Computing
   D.K. Arvind; *University of Edinburgh*
8. Synchronized relaxation oscillators harnessing correlated electron systems
   Suman Datta; *University of Notre Dame*

## WME 08:00-17:00

**Large Signal Network Analysis: From Instrumentation Architectures to Software Applications for Your RF Design Flow Improvement**
Sponsor: IMS; ARFTG

**Organizer:** Tibault Reveyrand, *University of Colorado,* Antonio Raffo, *University di Ferrara*

**Abstract:** This workshop focuses on large signal network analysis. This approach, more challenging than small-signal characterization, is a prime importance in the optimized design of RF circuits. The workshop addresses the instrumentation hardware architectures and the software tools that can solve high-efficiency linear amplification on various topologies (envelope tracking, Doherty, Outphasing transmitters,...). Instrumentation down-conversion is based on mixers (VNAs and VSAs), sub-samplers or tracking-and-hold amplifiers. Application tools include the last advancements on compact/behavioral modeling at transistor level but also on the methods to improve efficiency of your RF transmitter design thanks to waveform engineering. RF models and methods accuracy are upgraded by adding low-frequency dynamic characteristics of transistors. Design flow will be presented for a very large set of examples: from instrumentation, to transistors levels characterization (GaAs, GaN) up to complex architectures such as very high power amplifier for base station, Doherty, Outphasing and Varactors. The advantages of the large signal network analysis will be clearly illustrated and demonstrated.

1. Circuit-Based Transistor Modeling and Nonlinear Design using LSNA/NVNA Measurements
   Patrick Roblin; *Ohio State University*
2. A tour in the realm of vector-calibrated LSNA measurements: from low- to high-frequency, from characterization to design
   Gustavo Avolio; University Catholiqué de Louvain; Antonio Raffo; University di Ferrara; Giorgio Vannini; *University di Ferrara*; Dominique Schreurs; *University Catholiqué de Louvain*
3. Breakthrough in Wideband and High Resolution Calibrated Time Domain RF Measurement
   Denis Barataud; *University of Limoges*
4. Use of Nonlinear Vector Network Analyser Measurements in the development of GaN on Silicon for BTS applications
   Lyndon Pattison; *MACOM*; David Runton; *MACOM*; Andrew Patterson; *MACOM*
5. Advances in NVNA-based transistor characterization and modeling: Scalable X-parameter models, time-domain compact models, and new large-signal device measurements
   David Root; *Keysight Technologies*
6. NVNA measurements for high efficiency RF PA designs
   Tony Gasseling; *AMCAD Engineering*; Christophe Mazière; *AMCAD Engineering*
7. Design-oriented measurements of high-efficiency PAs for high PAR using an NI-based platform
   Zoya Popovic; *University of Colorado*; Tibault Reveyrand; *University of Colorado*
8. Characterization of advanced transmitter components using non-conventional LSNA measurements
   Mattias Thorsell; *Chalmers University of Technology*; Christer Andersson; *QAMCOM*; Sebastian Gustafsson; *Chalmers University of Technology*; David Gustafsson; *Ericsson*; Christian Fager; *Chalmers University of Technology*
9. Accelerating the design of high-efficiency power amplifiers using adapted measurement techniques
   Marc Vanden Bossche; *National Instruments Corporation*

## WMF 08:00-17:00

**Tunable and Reconfigurable Front Ends for Multiband Communication Systems**
Sponsor: IMS

**Organizer:** Xun Gong, *University of Central Florida,* Pierre Blondy, *XLIM CNRS - Universite de Limoges*

**Abstract:** The ever increasing demand for higher data rate wireless communication systems has lead to the adoption of a number of techniques like Multiband operation, Carrier agregation, and MIMO, in addition to the proposal of new techniques such as in-band full-duplex communications. These new techniques impose stringent RF requirements on the antenna interface components, like filters and amplifiers. As an example, multiband 4G smart phone would require about 16 duplexers for the main paths and 16 SAW/BAW filters for the diversity paths to cover the cellular bands in the 700-2700 MHz range. The antenna interface also includes the inevitable RF switches and antenna tuners. The antenna interface could be substantially simplified if a tunable RF filter with adequate performance can be practically realized. The advent of innovative switched capacitor array technologies such as stacked gate CMOS, Silicon on Sapphire, and MEMS technologies permits the development of a new generation of high linearity, low loss, and low power consumption tunable components. This workshop focuses on the area of tunable and reconfigurable RF/microwave filters, antennas and amplifiers by reporting recent research findings in this exciting field. This includes a large variety of novel planar/hybrid tunable circuit realizations for spectrum management and dynamic broadband filtering. The Workshop should highlight the trends and open the debate on choices in architecture, design, and technology of tunable RF filters and matching networks at the antenna interface.

1. Sharp Rejection and High-Q Tunable Filters Using High-Reliability RF MEMS Devices
   Gabriel Rebeiz; *University of California at San Diego*
2. Tunable RF Front-end Components: Design and Technology
   Dimitrios Peroulis; *Purdue University*
3. Multi-band Multi-function Tunable Filters
   Raafat Mansour; *University of Waterloo*
4. Dual-Band Tunable and Switchable Filters
   Pierre Blondy; *Centre National de la Recherche Scientifique*
5. Chip-scale Piezoelectric RF Microsystems for Frequency-dynamic Wireless Applications
   Songbin Gong; *University of Illinois at Urbana-Champaign*
6. RF-SOI for Tunable Radios
   Julio Costa; *QORVO, Inc.*
7. RF-MEMS Circuits for Wireless Applications
   Larry Morrell; *Cavendish Kinetics*
8. Tunable High-Efficiency Power Amplifiers with Variable Loads
   Zoya Popovic; *University of Colorado*
9. Design of Integrated Active Q- enhanced LC tunable filters with high dynamic range
   KJ Koh, Sanjay Raman; *Virginia Tech*

## WMG 08:00-17:00

**Heterogeneous Integration of Silicon RFIC with III-V's**
Sponsor: IMS

**Organizer:** Vesna Radisic, *Northrop Grumman Aerospace Systems,* Debabani Choudhury, *Intel Corporation*

**Abstract:** This workshop will focus on recent advances in heterogeneous integration of III-V and silicon RFIC technologies. This unique combination of these two technologies allows high integration level, yield, manufacturability of Silicon technology to be merged with high frequency and high performance III-V technologies. Several heterogeneous techniques will be presented including Zipronix direct bond interconnect technology and DAHI approach in which chiplets of one technology which are bonded to the wafer of different technology. Examples include integration of III-V's with SiGe BiCMOS , GaN with Si CMOS for RF applications, and of AlGaN/GaN devices on a scalable Si-CMOS platform. Challenges in implementation of GaN technology on large diameter, thin Si wafers due to large thermal and lattice mismatch issues will be also addressed. Another integration approach includes Nanoscale Offset Printing System (NanoOPS)that can print metals, insulators and semiconductors (including III-V and I-VI), organic and inorganic materials into nanoscale structures and circuits.

1. Leveraging Heterogeneous Integration for Modular RFIC Design
   Daniel Green; *Defense Advanced Research Projects Agency*
2. Diverse Accessible Heterogeneous Integration (DAHI) Foundry and Development Efforts at Northrop Grumman Aerospace Systems (NGAS)
   Dennis Scott; *Northrop Grumman Aerospace Systems*
3. Monolithic integration of AlGaN/GaN devices on a scalable Si-CMOS platform
   Ko-Tao Lee; *IBM T.J. Watson Research Center*
4. Wafer scale integration of III-Vs (GaN) with Si CMOS for RF applications
   Thomas Kazior; *Raytheon Company*
5. High-rate Nanoscale Printing for Electronics, Sensors, Energy and Functional Materials Applications
   Ahmed Busnaina; *Northeastern University*
6. Wafer Scale 3D Integration of High Performance III-V Devices and Silicon CMOS for mm-wave ICs
   Miguel Urteaga; *Teledyne*
7. Wafer-level heterointegrated InP DHBT / SiGe BiCMOS technology for mm-wave and sub-mm-wave applications
   Nils Weimann; *Ferdinand-Braun-Institut*
8. Synthesizer Improvement Using Reconfigurable Heterogeneous Integration of Silicon, Indium Phosphide and Gallium Nitride technologies
   Bryan Wu; *Northrop Grumman Aerospace Systems*

## WMH 08:00-17:00

**E-Band Communications: Market, Technology and IC Design**
Sponsor: IMS

**Organizer:** Edmar Camargo, *QuinStar Technology, Inc.*, Matthew Poulton, *QORVO, Inc.*

**Abstract:** E-band frequencies were allocated for communications more than 30 years ago, but interest in their commercialization did not occur until October 2003 when the FCC released a novel licensing plan for E-band (71 - 76 and 81 - 86 GHz), dedicated to high speed communications in the US. In 2006 the European organization ETSI followed similar actions. The concurrent development of 0.1 um GaAs, SiGe, InP and GaN technologies have in recent years provided impressive results in terms of high power density, low noise and low cost, allowing their application in E-band commercial and military systems for multi-Gb/s data rates in full duplex. Such systems are now being deployed in terrestrial, airborne and space applications. This workshop will cover mmWave transceiver design, focusing on different views of the markets by industry, performance achieved by different technologies, and the latest IC design improvements required by applications at these high frequencies. The transceiver components to be covered include frequency converters, power amplifiers and low noise amplifiers.

1. E-Band Communications at Raytheon: Technologies and Potential Applications
   James McSpadden; *Raytheon Company*; Mark Rosker; *Raytheon BBN Technologies*; Kenneth Brown; *Raytheon BBN Technologies*; Jagannath Chirravuri; *Raytheon BBN Technologies*; Hooman Kazemi; *Raytheon BBN Technologies*
2. Transceivers for Highly Spectral Efficient Multi-Gbps radio links
   David Ryan; *MaCom*; Simon Mahon; *MACOM*
3. Boosting E band communications using advanced III-V semiconductors
   Mansoor Siddiqui; *Northrop Gruman*
4. High performance low-cost fully-integrated SiGe based E-band transceiver chipset and packaging for fixed duplexing
   Oded Katz; *IBM Research - Haifa*
5. Development of linear GaAs MMICs for high performance E-band radios
   Marcus Gavell; *Gotmic*
6. Infineon E-band Front End Module for Cost-Optimized Gigabit DataLinks
   Uwe Rueddenklau; *Infineon Technologies AG*; Jagjit Singh Bal; *Infineon*
7. Three-Dimensional Wafer-Level Chip Size Package Technology and Application to E-band Communication Devices
   Tsuneo Tokumitsu; *Sumitomo*
8. Trade-offs in the Design of E-band Transceiver MMICs for Gigabit Wireless Link Application
   Suhill Kumar; *GigOptix*

## WMI 08:00-12:00

**Autonomous Vehicles**

Sponsor: IMS; RFIC

**Organizer:** Andreas Stelzer, *Johannes Kepler University of Linz,* Juergen Hasch, *Robert Bosch GmbH*

**Abstract:** Autonomous vehicles are being developed for a wide range of applications, from street cars, over unmanned aerial vehicles, to moving robots. A lot of effort is put into artificial intelligence and autonomous control algorithms. However, decisions are strongly dependent on real time information coming from sensors and infrastructure data. RF-technology plays a vital role in helping to get autonomous vehicles a reality, by providing a means for sensing and communication, independent of weather and light conditions. Robust and reliable sensing is a prerequisite to safely steer a vehicle in the right direction, by detecting the surrounding and recognizing obstacles. Communication is required to enable stable communication at an adequate data rate to ensure the autonomous vehicle receives all required information for navigation, and depending on the use case, for remote control. The workshop addresses recent topics related to autonomous vehicles, covering the required street communication infrastructure, current developments and future trends in autonomous driving, as well as some of the implementation aspects. Furthermore, a sensing and communication implementation for an aerial application will be presented. Additional presentations will highlight a UAV based test-bed and a robot swarm control. Finally, the implementation of a radar sensor based on novel integrated CMOS RF chips as basis for future radar sensors is presented.

1. The actual status of ADAS systems as of now and how to make it happen to let autonomous driving become a reality
   Holger Meinel; *Holger Meinel Consultant*
2. Vision and Roadmap to Fully Autonomous Driving
   Thomas Glaser; *Robert Bosch GmbH*
3. Radar sensing, system solutions and technology partitioning
   Cicero Vaucher; *NXP Semiconductors*
4. RF and image processing technologies for automatic flying platforms
   Volker Ziegler; *Airbus Group*
5. Radar Sensor Platform for UAV
   Andreas Stelzer; *Johannes Kepler University of Linz*; Reinhard Feger; *Johannes Kepler University of Linz*; And Haderer; *Inras GmbH*
6. Self-organizing 3D Wireless Local Positioning Networks for Robot Swarms
   Yassen Dobrev; *University of Erlangen-Nuremberg*; Christoph Reustle; *University of Erlangen-Nuremberg*; Martin Vossiek; *University of Erlangen-Nuremberg*

## WMJ 13:00-17:00

**Entrepreneurship 101 (TiE Silicon Valley)**

Sponsor: IMS

**Organizer:** R. Paul Singh, *TiE Silicon Valley,* Naeem Zafar, *TiE Silicon Valley*

**Abstract:** Since this year's conference is being held in Silicon Valley; the mecca of entrepreneurship and home to various startups, TiE Silicon Valley is putting together this beginner's workshop on Startups. TiE is a non-profit organization dedicated to helping entrepreneurs create wealth and give back to the community. TiE's mission is to foster entrepreneurship globally through mentoring, networking, education, incubating, and funding.

If you have ever thought of starting a company or thought of working for a startup or just intrigued with what it takes to create a successful startup, this workshop is for you.

Lead by R. Paul Singh and other successful entrepreneurs, this workshop will cover the following:

- Are you really to do a startup?
- What should a founding team of your startup look like?
- How and where to raise money for your startup?
- How to create a business plan that sells?
- Hard part begins after you raise money – What does that entail?

## SMA 08:00-17:00

**High-Speed Optical Transceiver Fundametals**
Sponsor: IMS

**Organizer:** Ricardo Saad, *Lumentum/University of Texas at Dallas*

**Abstract:** High-speed optical transceivers are one of the key technologies in the development of modern optical communications systems. The demand for more bandwidth due to the high growth on internet traffic has generated the need for optical transceivers that work at very high speeds. Optical transceivers operating at 400 Gbs and 1 Tbs will be deployed in the near future. Microwaves and high-speed optoelectronics are key technical areas for the development of the next generation optical transceivers. This short course introduces fundamental concepts of high-speed optical transceivers. Topics are presented in a step-by-step approach starting from fundamental electrical engineering concepts. Optical communication concepts are introduced at the beginning of the course to highlight the different applications and requirements for optical transceivers. The operation of key components such as high-speed photodiodes, lasers, electro-absorption and Mach-Zehnder modulators, transimpedance amplifiers, and drivers are introduced from a practical viewpoint. Different optical transceiver architectures and their corresponding implementations are presented. Design and characterization techniques of optical transceivers are reviewed. Impairments on optical transceivers are highlighted. The course concludes presenting different state-of-the art optical transceivers for multiple applications including optical transceiver for data centers.

## SMB 13:00-17:00

**Multi-Beam Antennas and Beam-Forming Networks**
Sponsor: MTT TC 16

**Organizer:** Piero Angeletti, *European Space Agency*

**Abstract:** Multi-Beam Antennas (MBAs) find application in several fields including wireless and satellite communications, RADARs for electronic surveillance and remote sensing, science (e.g. radio telescopes), RF navigation systems, etc. Beam-Forming Networks (BFNs) play an essential role in any antenna system relaying on a set of radiating elements to generate a beam. Depending mainly on the antenna mission (i.e. operational frequency, pattern requirements, transmitting and/or receiving functionality, number of beams to be generated, etc.) different MBA architectures may be selected: from antenna systems completely based on independent feeds illuminating a number of reflectors, to hybrid systems based on both arrays and reflectors, from phased arrays to lens antennas. The trade-off on the antenna solution largely involves the BFN interconnectivity and flexibility requirements, with a wide range of applicable BFN architectures with different complexity and performance. The objective of the course is to present design principles and state-of-the-art in MBAs and BFNs.