WORKSHOPS

Friday, 9 June 2017

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

WFA

08:00–17:00

Acoustic Multiplexer for Carrier Aggregation

Sponsor: IMS

Organizer: Andreas Tag, *Qorvo*; Holger Maune, Technische Universität Darmstadt; Amelie Hagelauer, *Institute for Electronics Engineering, University Erlangen-Nuremberg*

Abstract: As the wireless communication industry evolves from 3G to 4G LTE, there has been increasing demand for higher data rates with limited and fragmented spectrum. Therefore, carrier aggregation (CA) becomes the most important technology component in LTE-Advanced to achieve data rates up to 1 Gbps in the near future. For practical implementation of carrier aggregation in a highly compact smart phone device, acoustic multiplexers emerge as an indispensable technology, mainly due to small size, high Q and high linearity of acoustic resonators. This workshop will highlight the design and technology trade-offs of SAW, SMR, and FBAR for acoustic multiplexer applications in modern RF mobile front-ends. Eight excellent international speakers in a mix between academia and industry will target this topic. The speakers are well balanced between US, Europe, and Asia representing all major players in this field.

1. Towards Gigabits Per Second: Evolution of Mobile Terminal Front-End and Transceiver Architectures
   Harald Pretl, *University of Linz*
2. How Were Radio Frequency Surface and Bulk Acoustic Wave Devices Evolved? ---Learning from History---
   Ken-ya Hashimoto, *Chiba University*
3. Multiplexing Requirements in Carrier Aggregation – a Paradigm Shift in Acoustic Filter Design
   Yazid Yusuf, *Qorvo*; Gernot Fattinger, *Qorvo*; Robert Aigner, *Qorvo*
4. Multiplexers for Carrier Aggregation Applications
   Joerg Hornsteiner, *EPCOS AG*; Karl Wagner, *EPCOS AG*
5. Front-End Modules for Carrier Aggregation in Smart Phones
   Paul Bradley, *Broadcom*; William Mueller, *Broadcom*; Rich Ruby, *Broadcom*
6. Synthesis Methodologies for Acoustic Wave Filters and Multiplexers
   Pedro de Paco, *UAB*; Jordi Verdú, *UAB*
7. RF Acoustic Devices Using High Coupling/Temperature Compensation Materials and Applications for 4th and 5th Generation Systems
   Masanori Ueda, *TAIYO YUDEN Mobile Technology Co. Ltd.*; Osamu Kawachi, *TAIYO YUDEN Mobile Technology Co., Ltd.*; Makoto Inoue, *TAIYO YUDEN Mobile Technology Co. Ltd.*; Tsuyoshi Yokoyama, *TAIYO YUDEN Mobile Technology Co. Ltd.*; Shinji Taniguchi, *TAIYO YUDEN Mobile Technology Co. Ltd.*; Tokihiro Nishihara, *TAIYO YUDEN Mobile Technology Co. Ltd*
8. Lithium Niobate Laterally Vibrating Resonators and Comprising Filters for Carrier Aggregation
   Songbin Gong, *University of Illinois at Urbana Champaign*

WFB

08:00–17:00

Additive Manufacturing of Radio-Frequency Components

Sponsor: IMS

Organizer: Petronilo Martin-Iglesias, *European Space Agency*; Roberto Sorrentino, *University of Perugia*; Oscar Antonio Peverini, *CNR-IEIIT, National Research Council of Italy*; Thomas Weller, *University of South Florida*

Abstract: Additive Manufacturing (AM) has the potential to change how future space products are designed, integrated and operated. This technology is considered already as a strategic technology approach for space applications. AM will enable design for performance, mass customisation and easy design changes possible while also massively reducing the design/manufacturing/assembly cycle/costs as well as providing an environmental friendly alternative to conventional machining and is considered as key enabling technology for miniaturisation of complex small systems. AM can suppose a breakthrough technology for the development of RF hardware. The use of this manufacturing process can allows the manufactures of RF hardware to enhance the performance. RF, thermal and mechanical performance can be improved by using the additional freedom provided by AM. The assessment of different AM approaches has already started and will consider the whole process chain, including design, material supply, processing, post processing, qualification and verification, and standardisation. This assessment exercise is helping to identify already those AM approaches (materials, designs, processing, etc.) suitable for the manufacturing of RF hardware. However, the goal of AM is not to replace well known and consolidated manufacturing approaches such as milling, but exploits the additional freedom for advance designs. Simulation-based methods for engineering design and analysis have been in used and development for over 40 years and they have fundamentally changed the way products are designed. AM will push further the development of simulations tools able to exploit the advantages of AM.

1. Comparative Investigation of AM Technologies for the Manufacturing of Microwave Passive Waveguide Components
   Mauro Lumia, *CNR-IEIIT*; Oscar Antonio Peverini, *CNR-IEIIT*; Flaviana Calignano, *IIT*; Giuseppe Addamo, *CNR-IEIIT*; Elisa Paola Ambrosio, *IIT*; Diego Manfredi, *IIT*; Paolo Fino, *Politecnico di Torino*; Riccardo Tascone, *CNR-IEIIT*; Giuseppe Virone, *CNR-IEIIT*
2. Impact of AM in Satellite Payloads
   Petronilo Martin-Iglesias, *European Space Agency*
3. Bandpass Filters Optimised for the 3D Printing Process
   Michael Lancaster, *The University of Birmingham*; Xiaobang Shang, *The University of Birmingham*; Cheng Guo, *University of Electronic Science and Technology of China and The University of Birmingham (United Kingdom)*
4. RF and Microwave Filters and Other 3D Passive Components Made by Additive Manufacturing
   Aurelien Perigaud, *XLIM Research Institute*; Oliver Tantot, *XLIM Research Institute*; Nicolas Delhote, *XLIM Research Institute*; Stephane Bila, *XLIM Research Institute*; Serge Verdeyme, *XLIM Research Institute*; Dominique Baillargeat, *XLIM Research Institute*; Damien Di Marco, *SPCTS*; Pierre-Marie Geffroy, *SPCTS*; Thierry Chartier, *SPCTS*
5. Facing Very High Frequencies Through AM: a Strategic Approach
   María García Vigueras, *IETR-INSA Rennes*; Emile de Rijk, *SWISSto12*; Juan R. Mosig, *EPFL*
6. Metallic 3D Printed mmWave and THz Devices: How Far Can We Go On This Way?
   Bing Zhang, *National University of Singapore*; Yong-Xin Guo, *National University of Singapore*
7. 3D Printed GHz to THz Components and Systems
   Hao Xin, *University of Arizona*; Liang Min, *University of Arizona*
8. Tuneable 3-D Printing Technology for THz Applications
   William J. Otter, *Imperial College London*; Stepan Lucyszyn, *Imperial College London*
9. Laser-Based Layer-by-Layer Polymer Stereolithography for High-Frequency Applications
   Xun Gong, *University of Central Florida*; Jeff Maas, *Naval Surface Warfare Center Crane*; William J. Chappell, *DARPA Microsystems Technology Office*
10. Multi-Layer and Multi-Material Direct Digital Manufacturing for 3D RF/Microwave Applications
    Thomas Weller, *University of South Florida*; Jing Wang, *University of South Florida*

WORKSHOPS

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WFC 08:00–12:00

Amateur Radio as a Low-Cost Means of Providing Students with Practical RF Experience

Sponsor: IMS

Organizer: Ward Silver, *American Radio Relay League*

Abstract: Amateur radio integrated into the university level curricula is a novel and low-cost way for students to gain practical, hands-on experience with microwave and RF components, systems, and techniques. This workshop will present examples of university-level programs making such use of amateur radio in formal engineering curricula. The presenters will describe the positive impact of amateur radio on student learning and development, including the process of licensing and the type of materials required. Presenters will present examples of curricula and display student-constructed learning modules for attendees to examine. There will be a live demonstration of amateur radio, subject to the limitation of the available facilities. Information on amateur licensing will be available along with examples of available materials and displays of successful student activities.

1. Project-Based RF and Microwave Education Using Amateur Radio
   Robert Caverly, *Villanova University*
2. Ham Radio as a Replacement for English 101
   Allen Katz, *College of New Jersey and Linearizer Technology, Inc.*
3. Amateur Radio and Communication Engineering at Cologne University
   Rainer Kronberger, *Cologne University of Applied Sciences*
4. An I/Q Receiver for Project-Based RF in the Classroom
   Richard Campbell, *Portland State University*
5. Sophomore-Level Course in Radio Electronics at the University of Colorado, Boulder
   Zoya Popovic, *University of Colorado, Boulder*
6. Amateur Radio Licensing and Training for University Students
   Ward Silver, *American Radio Relay League*

WFD 08:00–17:00

Efficiency Enhancement and Linearization Techniques for Future Wireless Telecommunication Systems

Sponsor: IMS

Organizer: Andreas Wentzel, *Ferdinand-Braun-Institut Berlin*; Olof Bengtsson, *Ferdinand-Braun-Institut Berlin*

Abstract: The introduction of 5G in 2020 poses a great challenge in the development of future wireless infrastructure. Next-generation networks must ensure data rates up to 10 Gbps and modulation bandwidths up to 500 MHz, but also eliminate obstacles in today's communication systems, e.g., network reliability, accessibility, energy efficiency and latency. A denser spatial distribution of base stations, communication with MIMO, frequency and service agility of the hardware components as well as integration of the RFPAs into the antenna are pursued trends. The higher modulation bandwidth is enabled by operating the systems at higher carrier frequencies (6 GHz to mm-wave). Meanwhile, path loss increases and the distance between transmitter and receiver is decreased which enables smaller cells but requires more base-stations compared to the current 4G standard. The power per base-station as well as per RFPA hence reduces due to the distribution of the power to several PAs in the MIMO system. Linearizing such MIMO systems also poses a totally new challenge due to the possible RFPA crosstalk. The RFPA as the main energy consumer needs to satisfy the following essential requirements: high energy efficiency for high modulation bandwidths and large PAPRs. In addition, the role of DPD as a "wonder" linearizing method for the future systems can be questioned. The distribute nature of the system severely reduces the expected achievable efficiency improvement by standard DPD applied to each low power RFPA unit. Alternative solutions must be considered. In this workshop, industry and academic experts will discuss demands and various perspectives with regard to efficient, broadband and highly linear systems and circuit design techniques suitable for future wireless telecommunications such as 5G. Load and supply modulation techniques for large modulation bandwidths will be examined. New developments in multi-channel system modeling and measurements as well as appropriate linearization algorithms will be covered.

1. System, Technology and Requirements for 5G
   Franz Dielacher, *Infineon Technologies*
2. 5G System Challenges for User Equipment
   Paul Draxler, *Qualcomm Technologies, Inc.*
3. Broadband Envelope Tracking Systems
   Andreas Wentzel, *Ferdinand-Braun-Institut Berlin*; Nikolai Wolff, *Ferdinand-Braun-Institut Berlin*; Florian Huehn, *Ferdinand-Braun-Institut Berlin*; Sophie Paul, *Ferdinand-Braun-Institut Berlin*; Thomas Hoffmann, *Ferdinand-Braun-Institut Berlin*; Wolfgang Heinrich, *Ferdinand-Braun-Institut Berlin*; Olof Bengtsson, *Ferdinand-Braun-Institut Berlin*
4. Supply-Modulated X-Band GaN PA MMICs for Broadband High-PAPR Signals
   Zoya Popovic, *University of Colorado, Boulder*
5. System Measurements for 5G
   Mattias Thorsell, *Chalmers University of Technology*; Christian Fager, *Chalmers University of Technology*
6. MIMO Transmitter Modeling for Simultaneous Linearity and Efficiency Optimization
   Jose Carlos Pedro, *Universidade de Aveiro*; Telmo Cunha, *Universidade de Aveiro*; Pedro Cabral, *Universidade de Aveiro*; Filipe Baradas, *Universidade de Aveiro*
7. On the Application of the DPD Technique to Linearizing 5G Power Amplifiers
   Slim Boumaiza, *Emerging Radio Research Group, University of Waterloo*

WORKSHOPS

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WFE 08:00–12:00

Electromagnetic Theranostics: From Diagnostics to Treatment with Micro- and Millimeter Wave Sensors and Systems

Sponsor: IMS

Organizer: Margarita Puentes, *Technische Universität Darmstadt*; Christian Damm, *Technische Universität Darmstadt*

Abstract: Electromagnetic theranostic devices and systems have gained great interest in life sciences. The term theranostic describes the ability to diagnose a disease state in combination with the ability of therapeutic treatment of this disease state with the same device or system. This can be the detection of cancer with combined treatment in one single minimal invasive surgical intervention, but spans as far as to the recording and processing of neural activities and active feedback stimulation of muscles or the observation of cell/body reactions after a drug delivery by a system combining the observation and self-adaptive drug delivery. It will be shown that theranostic systems are a key solution for future personalized health care applications. The workshop will provide a good overview of state of the art research with biomedical applications from the tissue to the cellular and molecular level, as well as distinct enabling technologies related to power and data links specifically designed for implantable sensors and actuators. Real medical applications including dielectric spectroscopy and sensors for aqueous solutions applicable to cells and biomolecules integrated into microfluidic structures will be presented. The combination with specific manipulation of cells and molecules by different physical and chemical effects for theranostic systems will be emphasized as well. Furthermore, minimal invasive cancer detection and treatment using thermal ablation and minimal invasive plaque characterization for cardiovascular diseases diagnosis will be shown in detail. To cover all key aspects of theranostic systems, specific needs and solutions related to remote powering and interrogation of implantable sensors and actuators will be shown, including implants for neural recording and muscle stimulation. All applications have in common the use of electromagnetic fields from microwave to mm-wave frequencies for sensing, communication and manipulation purposes. These frequencies have several advantages over other approaches as will be shown.

1. Microwave and Millimeterwave Dielectric Sensing for Non-Destructive Molecular and Cellular Characterizations
   Katia Grenier, *LAAS-CNRS*
2. Modeling, Design, and Characterization of Microfluidic Microwave Heating Devices for Life Science Applications
   Ilja Ocket, *Imec and KU Leuven*
3. Minimal Invasive Microwave Devices for Theranostic Applications
   Margarita Puentes, *Technische Universität Darmstadt*
4. Microwave Plaque Characterization for Cardiovascular Diseases
   Jan Wessel, *IHP GmbH*
5. Enable Power and Data Telemetry for Peripheral Nerve Implants
   Yongxin Guo, *National University of Singapore*
6. Conformal Phased Surfaces for Wireless Powering and Interrogation of Bioelectronic Devices in Theranostic Systems
   John Ho, *National University of Singapore*

WFF 08:00–17:00

Emerging Transmission Line Technologies for Interconnect, Components, Circuits and Systems

Sponsor: IMS

Organizer: Anthony Ghiotto, *University of Bordeaux*; Maurizio Bozzi, *University of Pavia*; Vicente Enrique Boria Esbert, *Universitat Politècnica de València*

Abstract: A variety of applications have been recently proposed in the microwave and mm-wave frequency range, including wireless communications, power transfer systems, automotive radars, imaging sensors, and biomedical devices. The recent developments of the semiconductor and integration technologies and the circuit topologies have been leading to circuits and systems with outstanding performance, compact size and high reliability, and hence making the challenging applications feasible at a low cost. This workshop presents, in a coherent way, the recent advancements and novel achievements in microwave and millimeter-wave transmission line to realize high performance, compact and low-cost interconnections and RF front ends for emerging applications. The current trends and state-of-the-art developments in additive manufacturing and substrate integrated transmission lines, including that on SIW, air-filled SIW, ESIW and SISL will be presented, this includes packaging issues and the use of multilayer technologies. A 3D air-coax technology operating from dc to 200 GHz based on a wafer-level process will also be presented. In addition, the emerging approaches for mm-wave high speed interconnections based on polymer waveguides will be introduced. A variety of advanced topics will be covered by the presentations and will provide the attendees with a clear overview of the main streams of current and important research trends worldwide, in a field of absolute relevance for the members of the MTT-S. The speakers are well-known authorities in the field of integrated circuits and integration techniques at microwave and mm-wave frequency, coming from both academia and industry. A significant portion of time will be devoted to open discussion and interaction between the speakers and the audience.

1. ~~Additive Manufactured RF and mm-Wave Antenna Components~~
   ~~Emile De Rijk, *SWISSto12*~~
2. New Topologies and Material for Substrate Integrated Waveguide Components
   Maurizio Bozzi, *University of Pavia*
3. Reconfigurable and Miniaturized Substrate Integrated Waveguide Components
   Kamran Entesari, *Texas A&M University*
4. Novel Technologies Based on Empty Substrate Integrated Waveguides for Next-Generation of mm-Wave Transmission Lines and Components
   Angel Belenguer Martínez, *Universidad de Castilla La Mancha*; Vicente Enrique Boria Esbert, *Universidad Politécnica de Valencia*
5. Emerging Air-Filled SIW Technology for High Performance and Low-Cost Integrated Circuits and Systems at Millimeter-Wave and Beyond
   Anthony Ghiotto, *University of Bordeaux*; Frederic Parment, *University of Grenoble-Alpes*; Tan Phu Vuong, *IMEP-LaHC, Grenoble INP, Université Grenoble Alpes*; Ke Wu, *Ecole Polytechnique Montreal*
6. Emerging SISL Platform for High Performance Microwave and mm-Wave Circuits
   Kaixue Ma, *University of Electronic Science and Technology of China*
7. 3-D Air Dielectric Coax Miniaturized RF Networks
   Steve Huettner, *Nuvotronics*
8. Polymer Waveguides as an Alternative to Optical and Copper High-Speed Communication
   Patrick Reynaert, *KU Leuven*
9. Exploring Structural Integration and Physical Intelligence Through Mode-Diversity and Mode-Selectivity
   Ke Wu, *Ecole Polytechnique de Montréal*

WORKSHOPS

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WFG 08:00–17:00

GNSS Frontends, Antennas and Services

Sponsor: IMS

Organizer: Aly Fathy, *University of Tennessee*; Ozlem Kilic, *Catholic University of America*

Abstract: Now we can connect a laptop, smartphone or any wireless device to a BGAN portable satellite terminal for high-speed Internet and phone from anywhere in the planet. These terminals are small enough to be carried inside of a laptop case, yet deliver broadband speeds of up to 492 Kbps. Similarly, we can pinpoint the geographic location anywhere in the world. Using GNSS service. GNSS systems that are currently known are: the United States' Global Positioning System (GPS) and the Russian Federation's Global Orbiting Navigation Satellite System GLONSS. A third, Europe's Galileo. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations. The workshop will address the latest advances in antennas and RF frontends, and give overview for these different satellite services from academia, industry, and Government points of view.

1. GNSS Antennas for Future GNSS Signals
   Chris Bartone, *Ohio University*
2. Compact Multiband/Broadband Circularly Polarized Antenna for GNSS Applications
   Xiaodong Chen, *Queen Mary University of London*
3. Reception Systems with Compact Ring-Antenna Structures for GNSS and BGAN
   Iuliia Goncharova, *Institut für Hoch- und Höchstfrequenztechnik Universität der Bundeswehr München*; Simon Senega, *Institut für Hoch- und Höchstfrequenztechnik Universität der Bundeswehr München*; S Matthie, *Institut für Hoch- und Höchstfrequenztechnik Universität der Bundeswehr München*; Stefan Lindenmeier, *Institut für Hoch- und Höchstfrequenztechnik Universität der Bundeswehr München*
4. Small GNSS Antennas and Adaptive Arrays
   Andrew O'Brien, *Ohio State University*; John Volakis, *Ohio State University*
5. Compact Low Cost CP Antennas for GNSS and BGAN systems
   Robab Kazemi, *University of Tabriz*; Farhan Quaiyum, *University of Tennessee*; Aly Fathy, *University of Tennessee*
6. Design Considerations for a Man-Portable Anti-Jam GPS Antenna
   Steven Keller, *Army Research Lab*; Steven Weiss, *Army Research Lab*
7. Advances in Broadband Tunable and Interference Robust Receivers
   Chris Thomas, *MaXentric Technologies, LLC*
8. Low Power Multi-Mode Reconfigurable Techniques for GNSS Receiver
   Baoyong Chi, *Tsinghua University*
9. Smart Antennas for Mobile Satellite Communications
   Nemai Karmakar, *Monash University*
10. Pushing the Boundaries of Satellite Communications
    Jeff Palmer, *Global Satellite Engineering*

WFH 08:00–12:00

Localization in Wireless Sensor Networks

Sponsor: IMS

Organizer: Alexander Koelpin, *University of Erlangen-Nuremberg*; Jeffery Nanzer, *Michigan State University*

Abstract: Due to the expansion of research and development in the Internet of Things and cyber physical systems, wireless sensor networks (WSNs) will play a significantly larger role in the future. In most cases, the position of the sensors nodes is critical to the performance of the WSN, thus localization techniques are of considerable interest. Global positioning techniques, such as GPS and GLONASS, do not provide accurate enough positioning, in particular in environments where satellite signals cannot be detected or when the nodes are moving relative to one another. Therefore, local positioning techniques, where the nodes coordinate amongst themselves, are of particular interest. This workshop will give a comprehensive introduction to this topic covering all aspects from theoretical basics in localization, platform design of position aware sensor nodes, and practical examples for signal composition as well as positioning algorithms. The workshop content is illustrated by demonstrative real-world examples for industrial indoor positioning, localization in the Smart Home context and animal tracking. The required positioning accuracy and precision may vary for such systems, but the connecting link is in most cases the limit in resources concerning energy, weight, or size. Therefore, sophisticated resource aware techniques are required for all components of such systems starting from the system configuration, hardware topologies for the sensor nodes, algorithm partitioning between sensor node and base station up to the design of dedicated positioning signaling.

1. Spectrally Sparse High-Accuracy Microwave Wireless Positioning
   Jeffrey Nanzer, *Michigan State University*
2. Smart Home Low Power Wireless Sensor Network with Localization Functionality
   Felix Pflaum, *University of Erlangen-Nuremberg*; Alexander Koelpin, *University of Erlangen-Nuremberg*
3. Novel Localization Concepts with Advanced Low-Complexity Microwave and Millimeterwave RFIDs
   Christian Carlowitz, *University of Erlangen-Nuremberg*; Martin Vossiek, *University of Erlnagen-Nuremberg*
4. Wirelessly-Powered Area-Constrained UWB Localization Sensors for Batteryless Tracking Applications
   Arun Natarajan, *Oregon State University*
5. BATS: A System Approach for Animal Tracking in Resources Limited Wireless Sensor Networks
   Alexander Koelpin, *University of Erlangen-Nuremberg*; Joern Thielecke, *University of Erlangen-Nuremberg*

WORKSHOPS

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WFI 08:00–17:00

Low Cost Technology for Space Satellites

Sponsor: IMS

Organizer: Nuno Carvalho, *IT-Universidade de Aveiro*; Alessandra Costanzo, *University of Bologna*

Abstract: Satellite and Space industry is ready to enter a new era, the development of ICT (communication, remote sensing, IoT and so forth) is calling for a massive satellite deployment that, in turn, calls for a dramatic reduction of the cost of satellite technology and manufacturing, the latter being yet below the terrestrial wireless industry. In this workshop our proposal is to bring different actors in this area to discuss technology developments that could help to bridge this gap from terrestrial and satellite technologies and "to see the light of the day". Themes to be discussed are related to active antenna arrays, GaN technology for complete integrated transceiver MMICs, cube sat technology, potential technologies to be used in space for low cost systems, battery-less sensors and wireless power transmission applied to satellite systems. The WS would also like to investigate, overall, the present pursue-ability of short life time satellites and related technologies and architectures and also their eco-friendliness in view of a massive deployment of satellite debris in the atmosphere.

1. Cost Drivers for Low Cost Space Applications
   Rudy Emrick, *Orbital Sciences*
2. Software Defined Radio Approaches for Transceiver Design
   Nuno Carvalho, *IT-Universidade de Aveiro*; Pedro Cruz, *Instituto De Telecomunicacoes*
3. Advances in Multibeam Antennas and Beamforming Networks for Satellite Applications
   Piero Angeletti, *European Space Agency*; Giovanni Toso, *European Space Agency*
4. Reliable and Fast Switching Wireless Sensor Network for Space Application
   Jerzy Michlski, *Space Forest*
5. CubeSat Constellations of Millimeter-wave and THz Systems: Applications for Remote Sensing of Precipitation
   Steven Reising, *Colorado State University*
6. Next-Generation RFID Solutions for Localizing and Powering Objects in Space
   Alessandra Costanzo, *University of Bologna*
7. ~~MMIC Technology for Space~~
   ~~Václav Valenta, *European Space Agency*~~
8. "Downgraded" RF-Microwave Technology for Space Low Cost Satellites
   Luca Roselli, *University of Perugia*
9. Diversity-Methods for Robust Reception of Satellite Signals With Low Transmission Power in Mobile Applications
   Simon Senega, *Universität der Bundeswehr München*; Jürgen Röber, *Universität Innsbruck*; Thomas Ussmueller, *Universität Innsbruck*
10. GaN Microwave and Power Switching Opportunities for Applications in Space
    Hans-Joachim Würfl, *Ferdinand-Braun-Institut*

WFJ 08:00–12:00

Low-Cost CMOS mm-Wave Front-Ends for 5G Wireless Terminals

Sponsor: IMS

Organizer: Kamran Entesari, *Texas A&M University*; Tian-Wei Huang, *National Taiwan University*

Abstract: Rapidly growing demand for broadband cellular data traffic is driving fifth generation (5G) standardization towards deployment by 2020. The anticipated key to enabling gigabit-per-second 5G speeds is mm-wave operation. Millimeter-wave bands offer 50 times the bandwidth available in existing RF bands but pose numerous technical challenges to the low-cost deployment of millimeter-wave solutions. For example, U.S. regulators recently issued a notice of inquiry for provision of mobile services above 24 GHz. Additionally, reliable coverage over the typical 200 meter cell radius in non-line-of-sight dense urban conditions, and practical antenna array solutions for user equipment (UE) were both demonstrated at 28 GHz. High-volume implementation of the UE radio is also envisioned as multiple-element phased-array transceiver in silicon technologies. However, a great deal of discussion still surrounds how 5G standards and as a result their corresponding wireless accessories for UE will evolve. This workshop is focused on gathering a combination of experts in mm-wave integrated circuits to discuss integrated circuit solutions to potential mm-wave front-ends for different 5G standards. This workshop will present state-of-the-art research results in this area and ultimately help participants identify the enabling integrated radio technologies for 5G cellular communications.

1. Phased Arrays for 5G Systems at 28 GHz and 60 GHz
   Gabriel Rebeiz, *University of California, San Diego*
2. 60-GHz CMOS Transceiver for Heterogeneous 5G Network
   Kenichi Okada, *Tokyo Institute of Technology*
3. CMOS Front-Ends for 28 GHz 5G Terminals
   Kamran Entesari, *Texas A&M University*
4. Research Advances in Millimeter Wave Integrated Circuits for 5G
   Zhe Chen, *Southeast University*
5. 38-GHz CMOS TRX and Channel Model for 5G
   Zuo-Min Tsai, *National Chung Cheng University*
6. mmWave IC and Antenna-in-Package Design for Mobile Handsets
   Bodhisatwa Sadhu, *IBM T.J. Watson Research Center*

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WFK 08:00–17:00

Massive MIMO and its 5G Related Applications

Sponsor: IMS

Organizer: Abbas Omar, *University of Magdeburg*; Ahmed Kishk, *University of Concordia*; Jan Machac, *Czech Technical University in Prague*

Abstract: Massive MIMO is the term used by the Wireless-Communication community to describe large antenna arrays (together with the accompanying RF front-end and digital signal processing) that are essentially used by base stations to simultaneously communicate with multiple mobile and/or stationary units. It is expected that massive MIMO will play a key role in 5G and the tightly related Internet of Things (IoT) and Internet of Space (IoS) in terms of the target data rates (up to 10 Gb/s), latency (less than 1 ms), and energy consumption per transmitted bit (less than 1/1000 of the current one). This workshop is the first IMS forum, which will cover this rapidly evolving topic. The presenters are well known experts in the technical areas emphasized by the workshop. Besides the fundamentals, which will be overviewed in the opening talk, the workshop subject will be lighted up from both deterministic and stochastic perspectives. Deterministic coverage includes issues related to the design and optimization of large antenna arrays and their feed networks, mutual coupling between array elements, multi-band and multi-polarization operation, trade-off between digital beamforming and hardware phase shifters, and packaging of the RF front end and the antenna array. Channel modelling and issues related to diversity, data multiplexing, and information capacity highlight the stochastic coverage of the topic. The presentation post-discussions and mutual interaction between speakers and audience will lead to a comprehensive review of the current state of the art, the existing challenges, and the future outlook of this very promising area.

1. Overview on the Concepts of MIMO, Multiuser MIMO, and Massive MIMO
   Abbas Omar, *University of Magdeburg*
2. Multi-Mode Massive MIMO for Small Cell Ultra-High Data Rate Communication
   Dirk Manteuffel, *University of Hannover*; Peter Höher, *University of Kiel*
3. Precoding Techniques for Massive MIMO Systems
   Shahram Zarei, *University of Erlangen-Nürnberg*; Wolfgang Gerstacker, *University of Erlangen-Nürnberg*; Robert Schober, *University of Erlangen-Nürnberg*
4. Massive MIMO and the Effects of Imperfect Hardware
   Thomas Eriksson, *Chalmers University*
5. Novel Radar-Based Calibration Techniques for Massive MIMO Arrays
   Christian Carlowitz, *University of Erlangen-Nürnberg*; Patrick Gröschel, *University of Erlangen-Nürnberg*; Robert Schober, *University of Erlangen-Nürnberg*; Martin Vossiek, *University of Erlangen-Nürnberg*
6. Feasibility Assessment of a Cellular Neural Networks Based Channel Estimation Under Stochastic and Time-Varying Propagation Conditions
   Kyandoghere Kyamakya, *University of Klagenfurt*; Ahmad Mosa, *University of Klagenfurt*; Jean Chedjou, *University of Klagenfurt*
7. Large Antenna Arrays for Ultrahigh Data-Rate Indoor Communication
   Ahme Kishk, *University of Concordia*; Abbas Omar, University of Magdeburg

WFL 08:00–17:00

Materials and Devices for Next-Generation High-Q RF Resonators and Filters

Sponsor: IMS

Organizer: Christopher Nordquist, *Sandia National Laboratories*; Amir Mortazawi, *University of Michigan*

Abstract: Research and development in next-generation miniature and integrated high-Q resonator materials and technologies aims to address the explosive growth in the number and types of filters and resonators in modern wireless systems. These microscale resonator technologies combine integration of new materials and micromachining for novel device structures that provide benefits of smaller size, improved performance, and enhanced integration with electronics. Relative to incumbent surface acoustic wave (SAW) and bulk acoustic wave (BAW) technologies, these new technologies provide the potential for improved integration, tunability, and miniaturization. However, after more than a decade of research and many promising demonstrations of the potential performance and scalability of these technologies, the impact that these filter technologies will have on the massive wireless product market is still unclear. Like most emerging technologies, these resonators and filters pose many questions about the path to broad impact and commercialization. What are the most significant barriers to mass adoption of these technologies: maturity, cost, manufacturability, performance, integration, intellectual property, or some combination of these? What are the major technical challenges that must be addressed: bandwidth, impedance, stability, linearity, or other challenges? What is the most promising integration path: monolithic integration on CMOS, heterogeneous integration onto electronics, system-in-package, or another approach? Are there markets with intermediate volumes that will allow technology maturation and demonstration prior to adoption into mass market electronics? During this workshop, leading researchers will address the promises and challenges of these next-generation technologies, with an emphasis on answering these questions and identifying the potential routes to high-volume and high-performance applications. The presenters will provide both industry and academic perspectives on these issues and address the technical capabilities of these technologies in terms of bandwidth, reproducibility, manufacturability, tunability, linearity, cost, and integration.

1. Radio Frequency Passive Components Based on Aluminum Nitride Cross-Sectional Lamé Mode MEMS Resonators
   Matteo Rinaldi, *Northeastern University*
2. High kt2×Q, Multi-Frequency Lithium Niobate Resonators
   Sunil Bhave, *Purdue University*
3. Lithium Niobate MEMS Resonators and Filters: Ready for Prime Time?
   Songbin Gong, *University of Illinois Urbana-Champaign*
4. Beyond Aluminum Nitride: Piezoelectric Materials for RF MEMS Resonators
   Benjamin Griffin, *Sandia National Laboratories*
5. Challenges in Materials and Processing for Drastic Enhancement of RF SAW/BAW Device Performances
   Ken-ya Hashimoto, *Chiba University*
6. High Frequency, High Power, Single Crystal III-N BAW Devices
   Rama Vetury, *Akoustis*
7. Integration of PZT Resonators with PZT MEMS for RF Devices
   Ryan Rudy, *US Army Research Laboratory*
8. Intrinsically Switchable BST Filters
   Amir Mortazawi, *University of Michigan*

WORKSHOPS

Friday, 9 June 2017

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

WFM 08:00–12:00

Microwave Circuit Design for the Next-Generation Radar: 5G and Beyond

Sponsor: IMS

Organizer: Charles Baylis, *Baylor University*; Ali Darwish, *Army Research Laboratory*

Abstract: With the advent of the 5G wireless age, design issues of next-generation wireless communication systems are drawing much attention. Similarly, design of the next-generation radar poses significant challenges at the system, circuit, and device levels. This workshop focuses on circuit design issues related to radar systems to be deployed during the 5G era and beyond. Challenges include high-power, low-distortion design using microwave solid state and tube devices, spectrum sharing and dynamic frequency selection, and high-power tunable components. At the beginning of the workshop, attendees will participate in identifying specific challenging issues of interest related to next-generation radar design. Speakers will focus on the following topics: (1) next-generation radar system requirements, (2) circuit design with vacuum-tube technology and its limitations, (3) circuit design with solid-state technology (particularly GaN), and comparison of capabilities with radar system needs, (4) adaptive amplifier design to enable radars to reconfigure for dynamic spectrum allocation and real-time sharing with communications, and (5) novel technologies for high-power tunable radar components. Expert speakers from government, industry, and academia will discuss advances and challenges in these areas. The workshop will conclude with an attendee-driven panel discussion, including the workshop speakers, to develop a road-map for next-generation radar circuit design.

1. List of Issues for Next-Generation Radar Circuit Design
2. Design Challenges and Objectives for the 2030 Radar
   Ali Darwish, *Army Research Laboratory*; Ed Viveiros, *Army Research Laboratory*; Abigail Hedden, *Army Research Laboratory*
3. Microwave Tubes for the Next-Generation Radar
   Lawrence Cohen, *Naval Research Laboratory*; David Abe, *Naval Research Laboratory*
4. Solid-State Devices for Radar: Design Achievements and Challenges
   Steven Lardizabal, *Raytheon*
5. Adaptive Amplifier Design for Dynamic Spectrum Allocation in the Next-Generation Radar
   Charles Baylis, *Baylor University*; Robert Marks, *Baylor University*
6. Novel Technologies for High-Power Tunable Radar Components
   Dimitrios Peroulis, *Purdue University*
7. Panel Session: The Way Forward

WFN 08:00–12:00

Microwave Nano-Biotechnology

Sponsor: IMS

Organizer: Mitch Wallis, *National Institute of Standards and Technology*; Jim Booth, *National Institute of Standards and Technology*

Abstract: The field of nano-biotechnology sits at the intersection of two rapidly growing fields of research. The ongoing push to scale electronic devices to nanometer-scale has led to the discovery of new nano-materials and new physical phenomena. Meanwhile, new medical insights and treatments are now enabled by rapid advances in technology that harness our increased understanding of biological systems. Microwaves have a unique role to play in this cross-disciplinary field, for example by providing methods for non-invasive diagnostics and therapies. Furthermore, the development of body-area networks and communications will require a detailed understanding of the interaction of microwave and millimeter-wave radiation with biological systems. Finally, microwave measurements provide a platform non-destructive, spatially-resolved characterization of biological materials at microscopic and nanoscopic length scales. This workshop explores this emerging area, with emphasis not only on new applications, but also on establishing foundational understanding of the interaction of microwaves with biological systems at micrometer and nanometer length scales. One focus of the workshop will be the integration of microwave techniques with microfluidics for a number of applications, including quantitative determination of complex permittivity, local heating, and other microwave-based manipulation techniques. Also of particular interest are microwave probe techniques, including near-field scanning microwave microscopy. Application of such probes to cellular and sub-cellular systems provides non-destructive, subsurface measurement capabilities with nanometer-scale spatial resolution. The workshop brings together speakers from academia, government laboratories, and industry to explore how microwave engineering can play a vital role in this cross-disciplinary field.

1. Pushing Electromagnetic Characterization of Biological Cells Toward Nanometer Scale and Terahertz Frequency
   James Hwang, *Lehigh University*
2. Nanoscale Complex Impedance and Dielectric Properties of Single Cells and Bacteria at GHz Frequencies by Scanning Microwave Microscopy
   Georg Gramse, *Johannes Kepler University Linz*; Ferry Kienberger, *Keysight Technologies*
3. In-Liquid Near Field Microwave Sensing of Biological Cells
   Katia Grenier, *LAAS-CNRS*; David Dubuc, *LAAS-CNRS*
4. Development of the Near Field Scanning Microwave Microscopy for the Characterization of Subcellular Structures
   Marco Farina, *Universite Politecnica della Marche*
5. Microwave Microfluidics
   Nathan Orloff, *National Institute of Standards and Technology*; Charles Little, *National Institute of Standards and Technology*

WORKSHOPS

Friday, 9 June 2017

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WFO 08:00–17:00

Multi-Physics Based Microwave Modeling and Design

Sponsor: IMS

Organizer: Q.J. Zhang, *Carleton University*; Christian Damm, *Technische Universität Darmstadt*

Abstract: The past two decades have seen phenomenal progress in microwave modeling and optimization, along with dramatic changes in the computing environment, and the emergence of many new and exciting applications. High-fidelity EM modeling and optimization are now an essential part of microwave design. Engineers are solving more complex problems with EM-driven design than ever before. Multiphysics simulation has emerged from the realm of academic discussions to industrial necessity, and it is thereby entering the mainstream design arena. At the same time, computers are becoming much faster and cheaper, and we can do large-scale computations that were only dreams previously. On the other hand, new design challenges continue to arise. Design requirements are becoming more stringent. Component and circuit geometry are becoming more complex. Frequency becomes higher. Increased sophistication in multi-disciplinary modeling and design with coupling effects such as electromagnetics, thermal, mechanical stress, fluid dynamics, etc., are becoming increasingly necessary. Many practical examples are still too large, and too computationally prohibitive to be solved using today's computational tools and technology. Large-scale multiphysics simulation, coupled with increased design complexity such as requirements for manufacturability-driven statistical modeling and yield-driven design easily overwhelms the present computational capability. These challenges also present new opportunities for research and innovation. This workshop's distinguished experts from industry and universities will present their perspectives on these topics. The workshop session will also provide an opportunity for audience members to share their experiences and opinions and contribute to a lively discussion.

1. Solving Multi Domain Optimization Problems for Industrial Applications
   Peter Thoma, *CST*
2. Multiphysics Modeling of Microwave Power Devices
   Peter Aaen, *University of Surrey*
3. Multiphysics at the Core
   Zoltan Cendes, *ANSYS, Inc. (retired)*
4. RF Power Amplifier Design Using Nested Multi-Technology
   Kevin Kim, *NXP Semiconductors, N.V.*
5. Reducing Computational Complexity: A Need Never Out of Date
   Dan Jiao, *Purdue University*
6. Applying Multiphysics Simulations to the Development of Novel Dielectric Multimode Bandpass Filters
   Christoph Neumeier, *Spinner GmbH*
7. Multiphysics Optimization of Microwave Ablation Antennas and Biomedical Implants
   Costas Sarris, *University of Toronto*; Shashwat Sharma, *University of Toronto*; Hans-Dieter Lang, *University of Toronto*
8. Electromagnetic and Thermal Multiphysics Simulations of Highly Integrated RF Frontend Modules
   Winfried Simon, *IMST GmbH*
9. The Link Between Microwave-, Magnetostatic-, Thermal-, CAD-, Multipaction- and Stress Simulation That Makes the Difference in RF Component Design
   Siegbert Martin, *Tesat-Spacecom GmbH & Co. KG*
10. Multiphysics Based Modeling and Optimization for Microwave Design – Challenges and Opportunities
    Q.J. Zhang, *Carleton University*; Christian Damm, *Technische Universitat Darmstadt*

WFP 08:00–17:00

Plug and Play S-Parameter Measurements and Models for Broadband Interconnects

Sponsor: ARFTG; IMS

Organizer: Mike Resso, *Keysight Technologies*; Heidi Barnes, *Keysight Technologies*

Abstract: This workshop will provide an industry perspective on interconnect issues with reference plane placement and the subsequent impact on achieving high quality broadband s-parameter measurements and models. An overview will be provided from the historical challenges of the simple coaxial connector to understanding the latest in low power, high density, high speed interconnects for the Internet-of-Things (IOT). This IOT industry is rapidly moving towards new standards, such as the USB Type-C reversible interconnect that runs at 10Gb/s data rates creating microwave frequencies and is capable of 100 watts of power all in a PCB footprint that is smaller than a single edge launch SMA to PCB connector. Ensuring error free data transmission requires the ability to plug and play s-parameter models of various components for design exploration, turn-on debug, and compliance verification. Measurement calibrations and simulation reference planes need to pay careful attention to the definition and location of the s-parameter reference planes to insure the accuracy when cascaded in a full channel simulation across both time and frequency domains. Adding to the complexity is the high density coupling and crosstalk for signal integrity applications and the extremely low impedances on the power integrity side. This special session will include worldwide expertise in these engineering disciplines as well as academia to provide practical tips and techniques for measuring and modeling interconnects with custom calibration and simulation reference planes.

1. Printed Circuit Boards: The High Speed Electrical Interconnect of the Future
   Brett Grossman, *Intel*
2. Ideal Reference Plane for USB Type C Plug and Play S-Parameters
   Heidi Barnes, *Keysight Technologies*; Mike Resso, *Keysight Technologies*
3. Verifying De-embedding Processes With Plug and Play Separable Test Boards
   Eric Bogatin, *Bogatin Enterprises*; Mike Resso, *Keysight Technologies*
4. The "Connector Effect" and its Impact on High Frequency Measurement Accuracy and Repeatability
   Ken Wong, *Keysight Technologies*
5. Challenges of Using S-Parameters in Multigigabit Serial Links
   Howard Heck, *Intel*
6. Test Connector Interfaces Supported by Test Equipment Companies
   Bill Rosa, *Signal Microwave*
   Power Integrity Low ESR Measurements and Simulation
   Steven Sandler, *PicoTest*

WORKSHOPS

Friday, 9 June 2017

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WFQ 08:00–17:00

Recent Progresses in mmW Multilayer Circuit and System Design and Packaging (MCM/SoP)

Sponsor: IMS

Organizer: Kamal Samanta, *AMWT Ltd, UK*; Maurizio Bozzi, *University of Pavia*

Abstract: This workshop will discuss the recent advancement and state-of-the-art development in 3D and multilayer millimetre-wave multichip Module (MCM) and packaging (SoP) technologies. This will include multilayer additive manufacturing, such as inkjet, 3D and aerosol printing, for realizing advanced high quality embedded passive components, circuits and 3D stacked and MCM/SoPs architectures. At the same time, will present important progresses in highly integrated multilayer ceramic-based circuits (including active broadside and end-fire antenna arrays for 5G) and systems (like WiGig at 60 GHz and 5G system at 38GHz, space qualified systems at Ka-band, and 60 GHz air plane WLAN system),using and ceramic-stereolithography, and subtractive printing technologies (like LTCC, LCP and photoimageable TF). Further will present the novel Nano-fabrication of CNTs based sensors on flexible substrates and mmW interconnects for flip-chip integration and packaging. The workshop will also provide various examples in the area of multifunction packaging, high-Q passives and energy harvesting/transfer techniques, Internet of Things (IOT), flexible platform, wearable electronics, 60 GHz WLAN and WiGig and sensor networks and 5G systems (including analog/RF beamforming.

1. Millimeter Wave System Design and Realization Using Multilayer LTCC
   Ingo Wolff, *IMST*
2. Inkjet-/3D-/4D- Printed Paper/Polymer-Based "Green" mmW Modules: The Final Step to Bridge Cognitive Intelligence, Nanotechnology and RF for IoT and 5G Applications
   Manos M. Tentzeris, *Georgia Institute of Technology*
3. Cost-Effective Ceramic-Based Multilayer Circuit and Systems Beyond 100 GHz
   Kamal Samanta, *AMWT Ltd*
4. Additive Manufacturing for RF to mm-Wave Multilayer and 3D Structures.
   Dominique Baillargeat, *University of Limoges*
5. Additive Manufacturing of RF to THz Components and Circuits: Opportunities and Challenges
   John Papapolymerou, *Michigan State University*; Premjeet Chahal, *Michigan State University*
6. 3D Integrated Microwave and Millimeter Wave Components and Modules
   Tauno Vaha-Heikkila, *MilliLab, VTT Technical Research Centre of Finland*
7. Efficient Radar Front-End Implementation in LTCC Multilayer Cavity Technology
   Alexander Koelpin, *University of Erlangen*; Armin Talai, *University of Erlangen-Nuremberg*
8. System and Package Design Using Organic Multilayer Substrate with Embedded Antenna Array for WiGig and Future 5G Communication at 38 GHz
   Hsin-Chia Lu, *National Taiwan University*
9. Inkjet and 3D Printed Circuits for Energy Harvesting, Communication and Sensing
   Apostolos Georgiadis, *Heriot-Watt University*

WFR 08:00–17:00

RFID Components and Devices for the Next Generation of 5G IoT Devices

Sponsor: IMS

Organizer: Thomas Ussmueller, *Institute of Mechatronics, University of Innsbruck*; Jasmin Grosinger; *Institute of Microwave and Photonic Engineering, Graz University of Technology*

Abstract: When 5G, the fifth generation of wireless communication technologies, arrives in 2020, engineers expect that it will be able to handle about 1000 times more mobile data than today's cellular systems. 5G will then become the backbone of the Internet of Things (IoT) linking up fixed and mobile devices becoming part of a new industrial and economic revolution. The radio frequency identification (RFID) technology is one of the key enabling technologies for the IoT. The main benefit of RFID systems for IoT devices is the possibility to operate these devices batteryless. Hence, no maintenance for the wireless interface is necessary resulting in a theoretically unlimited lifetime of the wireless IoT devices. To be prepared for the arrival of 5G and the next generation of 5G IoT devices, RFID components and devices should offer a reliable and robust operation and functionalities. The workshop covers a collection of important topics on RFID components and devices for the next generation of 5G IoT devices including antenna design for RFID, energy harvesting, novel technology developments and use cases for RFID-based sensor nodes.

1. Backscatter Communications, the Next IoT Radio Paradigm
   Nuno Borges Carvalho, *Universidade de Aveiro*
2. RFID Sensors & Actuators
   Manuel Ferdik, *University of Innsbruck*
3. Inkjet-/3D-Printed "Green" RFID and Wireless Sensor Modules: The Final Step to Bridge Cognitive Intelligence, Nanotechnology and RF for 5G IoT Applications
   Manos M. Tentzeris, *The Georgia Institute of Technology*
4. Ultra Low Power, Compact and Energy Harvesting Assisted Wireless Sensors for IoT Applications
   Apostolos Georgiadis, *Heriot-Watt Univ*
5. Spectrally-Efficient RFID and Backscatter Sensors
   John Kimionis, *The Georgia Institute of Technology*
6. Miniaturized RFID Transponders and Passive Read Range Boosting Techniques
   Jasmin Grosinger, *Graz University of Technology*; Wolfgang Bösch, *IGraz University of Technology*
7. Computational Techniques for Antenna Designs Related Internet of Things (IoT)
   C. J. Reddy, *Altair Engineering, Inc*
8. Antenna Systems Architectures for Simultaneous Far-Field Communication and Near-Field WPT
   Alessandra Costanzo, *University of Bologna*; Diego Masotti, *University of Bologna*; Francesco Berra, *University of Bologna*; Massimo Del Prete, *University of Bologna*
9. Substrate-Integrated-Waveguide-Based Antenna Systems for 5G and the Internet-of-Things
   Sam Agneessens, *Research Foundation Flanders, FWO, imec*; Olivier Caytan, *Ghent University*; Thomas Deckmyn, *IDLab, imec*; Sam Lemey, *Ghent University*; Hendrik Rogier, *Ghent University*
10. Wearable Printed Antennas for 5G and the Internet-of-Things
    Smail Tedjini, *University Grenoble Alpes*; Pierre Lemaitre-Auger, *University Grenoble Alpes*; Tsitoha Andriamiharivolamena, *Intel Mobile Communications Lab*

WORKSHOPS

Friday, 9 June 2017

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WFS 08:00–12:00

Thermal vs Non-Thermal Effects of Electromagnetic Waves for Biomedical Applications

Sponsor: IMS

Organizer: Cristiano Palego, *Bangor University*; Arnaud Pothier, *XLIM*

Abstract: Unquestionably, electromagnetic fields (EMF) from low to millimeter-wave frequencies present strong and increasing interest for biological and medical applications. Although the interaction of electromagnetic fields and life processes has been studied and debated for more than half a century, understanding the biological effects of microwaves is still complex and controversial. The existence of non-thermal effects of polarized radiation has been suggested and made the object of preliminary investigation in the last few years. However, separation and identification of thermal and non-thermal effects remains challenging at the micro-scale and for non-homogeneous dielectric media. While providing a means for disentanglement of thermal and non-thermal effects, exposure of biological tissues and individual cells to very short electromagnetic pulses has demonstrated great potential for biomedical applications such as genetic modification, drug delivery and cancer treatment. The reported advances in microwave spectroscopy, technology integration and broadband characterization will shed new light on the exposure conditions to stimulate internal biological cell process as well to enhance tissue recovering. Dedicated micro-scale structure for separation of electric and magnetic field effects along with the utilization of sub-cellular fluorescent reporters will be additionally presented for enhanced understanding of microwave-induced cardiac dysfunction and improvement of thermal ablation therapy. The aim of this workshop is to address the recent advances in microwave and millimeter-wave technologies dedicated to electromagnetic waves exposure of living systems and their promising use for biomedical applications and health related treatments.

1. Advanced RF, Microwave and Millimeter Wave Energy Based Systems to Address A Range of Unmet and Growing Clinical Needs
   Chris Hancock, *Creo Medical Ltd*
2. Irreversible Electroporation for the Treatment of Brain Cancer
   Rafael Davalos, *Virginia Tech – Wake Forest University*
3. Dynamic Dielectric Response of Single Cells Exposed to Pulsed Electric Fields
   Greg Bridges, *University of Manitoba*
4. Biomolecular Mechanisms Underlying Non-Thermal Cellular Responses to Microwave Frequency Electric Fields
   Catrin Williams, *Cardiff University*; David Lloyd, *Cardiff University*; Adrian Porch, *Cardiff University*
5. Bi-CMOS Microfluidic Microwave Platform for Biological Cell Sensing and Manipulation
   Mehmet Kaynak, *IHP microelectronics*; Arnaud Pothier, *XLIM Research Center*; Cristiano Palego, *Bangor University*

WFT 08:00–17:00

Towards 5G: New Trends in Microwave Filters

Sponsor: IMS

Organizer: Cristiano Tomassoni, *University of Perugia*; Maurizio Bozzi, *University of Pavia*

Abstract: This workshop presents, in a coherent way, the current trends in the development of microwave filters, with a particular outlook on the systems for 5G applications. The development of 5G networks poses new requirements to microwave designers, and in particular to filter developers. The use of millimeter-wave frequencies, the need to miniaturize and integrate complete wireless systems, the close interaction with the Internet of Things (and probably the Internet of Space), and the advent of new manufacturing techniques (like 3D printing) are bound to change the way we design and fabricate filters today. All these topics are very central for the current fields of interest and the future orientation of the MTT Society and of great relevance for the microwave community. The presentations of this workshop will cover both theoretical aspects (related to novel filter topologies, miniaturization issues, synthesis techniques) and technological topics (like filters for space applications and new material for the Internet of Things), to provide the attendees with a clear picture of the relevant research areas in this field. Outstanding speakers from America, Europe, and Asia (all confirmed) will cover all these research areas in a thorough and coherent way, with significant time devoted to questions and interaction with the audience. This approach will make the workshop very different from traditional conference sessions, where a thorough description of the topics is not possible and the interaction with the attendees is limited by time constraints.

1. ~~Unique Fabrication Technology for Implementation of a Unique MM Filter~~
   ~~Richard V. Snyder, *RS Microwave*; Simone Bastioli, *RS Microwave*~~
2. High-Q Multi-Band Filters
   Raafat R. Mansour, *University of Waterloo*
3. Substrate Integrated Waveguide Filters: Novel Geometries and Innovative Materials for 5G Applications
   Cristiano Tomassoni, *University of Perugia*; Maurizio Bozzi, *University of Pavia*
4. Implementation of Advanced Filtering Functions
   Stephane Bila, *XLIM*
5. Novel Topologies of Waveguide Filters for Satellite Payloads Including Practical Manufacturing Considerations
   Vicente E. Boria-Esbert, *Technical University of Valencia*; Marco Guglielmi, *Polytechnic University of Valencia*
6. Dual-Channel Dielectric Filters and Their Applications to 5G Massive MIMO Systems
   Xiu Yin Zhang, *South China University of Technology*; Jin-Xu Xu, *South China University of Technology*
7. Multiple-Mode Resonator (MMR) Technique for Applications in Design of Low-Loss Cavity Filters and Diplexers
   Sai-Wai Wong, *South China University of Technology*; Lei Zhu, *University of Macau*
8. Design of Compact Filters Based on Dual Composite Right/Left-Handed Unit Cells
   Wenquan Che, *Nanjing University of Science and Technology*; Guangxu Shen, *Nanjing University of Science and Technology*
9. Advances on Synthesis Techniques for Microwave Filters and Multiplexers
   Giuseppe Macchiarella, *Polytechnic of Milan*

SHORT COURSES

Friday, 9 June 2017

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

SFA 08:00–17:00

Multi-Beam Antennas and Beam-Forming Networks
Sponsor: IMS

Organizer: Piero Angeletti, *European Space Agency*; Giovanni Toso, *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.

SFB 08:00–12:00

RF Sampling Architecture for High Bandwidth Communication Systems
Sponsor: IMS

Organizer: Russell Hoppenstein, *Texas Instruments*

Abstract: Next generation communications systems need more signal bandwidth capability to handle increased data rates and to provide more network capacity. Direct RF sampling data converters operate in the multi-GHz range to directly capture or generate signals in the RF band. The RF sampling converters also support very large signal bandwidths (currently over 1-GHz) that were not possible with previous architectures. The course will illustrate the key technical challenges related to system noise figure, spurious performance, and intermodulation distortion. The course will provide techniques and examples of proper frequency planning with RF sampling converters to relax analog filtering requirements and to minimize spurious impact. The RF analog-to-digital converter (RF ADC) includes a digital down-converter (DDC) to reduce the output data rate and improve signal-to-noise (SNR) performance. The RF digital-to-analog converter (RF DAC) includes a digital up-converter (DUC) to keep the input data rates at reasonable levels while maintaining a high output sample rate. Integrated Numerically Controlled Oscillators (NCOs) allow the user to capture/generate signals to any desired bands. This course will highlight the key system parameters related to RF sampling converters for designing high bandwidth transceivers in high performance communication systems like 5G wireless infrastructure.

SFC 08:00–17:00

The Dynamics, Bifurcation, and Practical Stability Analysis/Design of Nonlinear Microwave Circuits and Networks
Sponsor: IMS

Organizer: Almudena Suarez, *University of Cantabria, Santander*; Christopher Silva, *The Aerospace Corporation*

Abstract: This full-day course addresses the fundamental topic of stability in nonlinear microwave circuits and networks (MCNs), covering concepts, qualitative analysis, simulation, and engineering design. The many unique qualitative behaviors possible in common nonlinear MCNs will be illustrated, as well as the fundamental means by which these behaviors can abruptly arise with parameter changes (termed a bifurcation). Course attendees will learn about different types of steady-state solutions, identify instability problems through small- and large-signal stability analysis in the time/frequency domains, and understand dynamical mechanisms responsible for instabilities. The primary approaches for stability analysis will be presented and compared, ranging from classical (e.g., Rollet factor, stability circles) to advanced that can be implemented using classical harmonic balance methods. The most common bifurcations will be described, enabling designers to confidently identify them in measurement/simulation. Practical examples of instability, stability analysis, and stabilization design will be presented for such important MCNs as power amplifiers, frequency multipliers/dividers, and voltage-controlled oscillators. Finally, the vast research area on harnessing nonlinear dynamics for engineering purposes will be surveyed, providing a glimpse into future nonlinear designs. The course will include video/hardware demonstrations of bifurcation and nonlinear qualitative behaviors, as well as several live stability analysis sessions using ADS.