Programme
09:00 - 09:10 Welcome and Introduction
09:10 - 09:55 Tuneable RF and Microwave Component Technologies Based on Functional Materials
Holger Maune and Rolf Jakoby, Technische Universität Darmstadt, Germany
09:55 - 10:40 LTCC Based Tuneable and Reconfigurable Microwave Components
Atif Shamim, King Abdullah University of Science & Technology, Saudi Arabia
10:40 - 11:20 Coffee Break
11:20 - 12:10 Microwave and Millimetre Wave Adaptive Components and Radios
Tauno Vähä-Heikkilä, MilliLab, Finland
12:10 - 13:00 Agile Front Ends for Mobile Radios
Arthur Morris, WiSpry, Inc., USA
13:00 - 14:20 Lunch Break
14:20 - 15:10 Adaptive RF-front-End Filtering Solutions
Dimitrios Peroulis, Purdue University, USA
15:10 - 16:00 Reconfigurable Microwave Planar Filters
Jia-Sheng (Jason) Hong, Heriot-Watt University, UK
16:00 - 16:40 Coffee Break
16:40 - 17:15 Multiband Tuneable Filters and Antennas with Innovative Technologies
Pierre Blondy, XLIM, University of Limoges, France
17:15 - 17:50 RF-Power-Dependent Reconfigurable Filters and Multiplexers for Frequency-Selective Limiting
Andrew C. Guyette and Eric J. Naglich, Naval Research Laboratory, USA
17:50 - 18:20 Microfluidically Tuneable Miniaturized Microwave Filters with Watt-level Power Handling
Kamran Entesari, Texas A&M University, USA

WM01
Reconfigurable RF & Microwave Passive Components for Emerging Wireless Systems

Organisers:
Roberto Gómez-García, University of Alcalá, Madrid, Spain
Dimitra Psychogiou, Purdue University, West Lafayette, IN, USA

Abstract
Latest trends towards the development of modern frequency-agile multi-mode RF front-ends for emerging wireless applications (e.g., software-defined-radio (SDR) transceivers for 5G and multi-functional radars) create new challenges in the field of reconfigurable microwave electronics as enabling technologies. New requirements especially extend to the area of Tuneable RF/microwave passive components (e.g., filters for signal-band pre-selection and interference mitigation, phase shifters, matching networks, and antennas) as they can be found in basically all high-frequency transmitter and receiver chains. The aim of this workshop is to provide an overview of the most recent research findings in the exciting area of reconfigurable RF/microwave passive components. This includes the development of sophisticated Tuneable RF/microwave passive devices that exploit advanced materials and non-conventional techniques for tuning, such as Liquid Cristal (LC), Barium Strontium Titanate (BST), multi-layer low-temperature co-fired ceramic (LTCC), and microfluidic principles to cover frequency ranges starting at the microwave range and covering up to the sub-THz band with advantages in terms of frequency agility, power handling, and DC-power-bias saving. Advances at the circuit-architecture level through several examples of unprecedented reconfigurable passive devices, such as RF-power-dependent reconfigurable filters, multiplexers and Tuneable high-Q filters based on controllable cavities and hybrid acoustic-lumped-element technologies, will be presented. Moreover, the implications and expected operational benefits from the integration of these adaptive RF/microwave passive components in fully-tuneable RF front-ends will be discussed.
**WM02**  
**Millimetre-Wave Electronics for High Capacity Wireless Networks**

**Organisers:**  
Claudio Paoloni, Lancaster University  
Valerio Frascolla, Intel Deutschland GbmbH

**Abstract**  
The quantum leap for high capacity everywhere will be born from a new generation of wireless networks at mm-wave frequencies. Only those frequencies bands are wide enough to support the multigigabit data rate targeted by 5G networks. The challenge is formidable, due to the combination of a millimetre wave technology which is not yet completely mature and the link obstacles such as atmospheric attenuation, diffraction, range.

This workshop will offer the vision on the state of the art in the field of millimetre wave wireless networks through the latest update from renowned experts from operators, electronic manufacturers and academia. The complementary synergies of two large Horizon 2020 projects, mmMAGIC and TWEETHER, will disclose new routes for an integrated approach, for developing new electronic components and systems to define new architecture for anticipating the future of wireless communications.

This workshop is oriented to operators, service providers, manufacturers and academics in the field of wireless communications systems. Four high calibre keynote speakers and six thematic talks will provide the audience an outstanding overview on millimetre wave wireless networks and stimulating concepts and materials for a lively and constructive discussion. We expect to seed a fresh vision for the future wireless communication paradigms.

A World Café will close the workshop to link ideas within a large group to leverage on the “collective intelligence” in the room: participants move among a series of small groups/tables where they continue the discussion in response to a set of questions, which are predetermined and focused on the specific goals of the workshop.

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**Programme**

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<th>Time</th>
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<td>09:00</td>
<td>Welcome and Introduction of the Workshop</td>
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| 09:10    | Keynote: Millimetre-Wave as the Key Technology to Solve the Backhaul and Front-Haul Bottleneck for the Next Generation Mobile Networks  
Renato Lombardi, Huawei, Italy |
| 09:40    | Millimetre-Wave Transceiver Design for Multi-Gigabit Mobile Backhaul Applications  
Chris Buck, Filtronic, UK |
| 10:00    | Keynote: Millimetre-Wave Radio Systems - The Next Frontier  
Andy Sutton, BT, UK |
| 10:40    | Keynote: The mmMAGIC Project: New frontiers in 5G Mobile Communications and Network Architecture Above 6 GHz  
Maziar Nekovee, Samsung, UK |
| 11:20    | Keynote: 6-100 GHz Channel Modeling for 5G: Perspective and Outcomes of mmMAGIC  
Wilhelm Keusgen, Fraunhofer Heinrich-Hertz-Institute, Germany |
| 12:00    | Coffee Break |
| 13:00    | Lunch Break |
| 14:20    | Opening of the Second Part of the Workshop                             |
| 14:35    | Keynote: Radio Interface Design for mmwave Mobile Radio Access Networks  
Jian Luo, Huawei Technologies Dusseldorf GmbH, Germany |
| 15:10    | Coffee Break |
| 16:00    | Keynote: Millimeter Wave Antenna Technology Evolution: From Wi-Fi to 5G  
Alexander Maltsev, Intel Corporation, Germany |
| 17:10    | World Café |
| 18:00    | Open Discussion and Concluding Remarks                                 |
WM03
Additive Manufacturing for RF Passive Hardware

Organisers:
Petronilo Martin-Iglesias, European Space Agency
Cesar Miquel-España, European Space Agency
Jaione Galdeano, European Space Agency

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 optimization and easy design changes while also massively reducing the design/manufacturing/assembly cycle/costs as well as providing an environmentally friendly alternative to conventional machining. AM is also considered as key enabling technology for miniaturisation of complex small systems.

AM can be considered a breakthrough technology for the development of RF hardware. The use of this process allows the manufacture of RF hardware to achieve enhanced performance. RF, thermal and mechanical performance can be improved by using the additional design freedom provided by AM.

The assessment of different AM approaches for RF hardware 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.) best suited 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 to exploit the additional freedom for advanced designs.

This workshop will be focused in three main aspects related to the use of AM for the manufacturing of RF hardware.

The first part will introduce the AM process and review its features. The suitability of AM for the space sector will be also addressed. In the second part, the impact of AM in satellite systems will be presented followed by the third part where some manufacturing approaches and real examples will be presented by companies and universities.

Programme

09:00 - 09:15 Welcome
09:15 - 10:00 Challenges within End-To-End Additive Manufacturing of RF Components for Space Use
    Johannes Gumpinger, European Space Agency, Noordwijk, The Netherlands
10:00 - 10:40 Impact of AM in Satellite Payloads
    Petronilo Martin-Iglesias, European Space Agency, Noordwijk, The Netherlands
10:40 - 11:20 Coffee Break
11:20 - 11:55 Performance Enhancement for Waveguide Filters Using Additive Manufacturing
    Paul Booth, Airbus DS UK, Stevenage, United Kingdom
11:55 - 12:30 Additive Manufacturing of Waveguide Low-Pass Filters By Selective Laser Melting: Lessons Learned
    Giuseppe Addamo, IEIIT, Turin, Italy
12:30 - 13:00 3D Manufacturing of Microwave Components for Space Applications
    Jose Lorente, TESAT, Backnang, Germany
13:00 - 14:20 Lunch Break
14:20 - 14:50 An Educational Perspective of Low-Cost Additive Manufacturing by Fused Filament Fabrication of Microwave Waveguide Passive Devices
    Jose Ramon Montejo-Garai, UPM, Madrid, Spain
    Nicolas Delhote, XLIM, Limoges, France
15:25 - 16:00 High Performance Additive Manufactured RF Waveguide and Antenna Components for Aeronautical and Space Applications
    Emile de Rijk, SWISSto12, Lausanne, Switzerland
16:00 - 16:40 Coffee Break
16:40 - 17:20 3-D Printed Metal-Pipe Rectangular Waveguides
    Stepan Lucyszyn, William J. Otter, Imperial College London, United Kingdom
17:20 - 18:00 Metallic 3D Printing Technology for Millimetre-Wave and Terahertz Applications
    Bing Zhang, Herbert Zirath, Chalmers University of Technology, Göteborg, Sweden
18:00 - 18:20 Open Discussion and Concluding Remarks

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### Organisers:
Nuno Borges Carvalho, Instituto de Telecomunicacoes, Universidade de Aveiro, Portugal
Alessandra Costanzo, University of Bologna, Italy

### Abstract
Wireless Power Transmission is a technology that has existed for many years. It goes back to Nichola Tesla. Nevertheless technology was not mature enough to consider it as a solution for high reliability requirements.

Recently the WPT technology gained a new breakthrough with a significant number of commercial applications appearing on earth-based applications, which created a wave of interest not only for near field WPT as is used in most of the earth-based solutions, but also for far field solutions which seems to have much more interest in space solutions where several techniques could be used with different legal framing.

In this workshop the main objective is to discuss and to explore WPT in space environments and address potential solutions for space applications, spanning from WPT satellites, WPT for space shuttles, WPT Technologies for Space Solar Power, Beam Efficiency of Beam-Type Wireless Power Transfer via Radio Wave with Phased Array.

The speakers cover different international quadrants, from USA, Japan and Europe. It is expected that the workshop talks and subsequent discussions would allow a new vision and promote ideas in this new emerging technology field.

### Programme

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<td>Opportunities, Challenges and Recent Advances in Wireless Power Technologies for Space Solar Power Paul Jaffe, U. S. Naval Research Laboratory - Naval Center for Space Technology, Washington, USA</td>
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<td>09:55</td>
<td>Impact of Modulation Scheme on Rectifier RF-DC Efficiency and Optimal Input Signal Control Technique Kenjiro Nishikawa, Kagoshima University</td>
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<td>11:20</td>
<td>Circuit and System Solutions for Dynamic RF Energy Transfer</td>
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<td></td>
<td>Alessandra Costanzo, DEI, University of Bologna</td>
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<td>12:05</td>
<td>Powering up Space Probes</td>
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<td>Nuno Carvalho, Instituto de Telecomunicacoes- Universidade de Aveiro</td>
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<td>14:20</td>
<td>Autonous WPT System with Multiple Controlled Propagation Directions for Receivers Distributed In 3D Space Jerzy Michalski, SpaceForest, Gdansk, Poland</td>
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<td>15:05</td>
<td>High-efficiency and Ultra-Compact Microwave Rectenna for Space Applications Alexandru Takacs, CNRS, LAAS, Toulouse, France</td>
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<td>16:00</td>
<td>Coffee Break</td>
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<tr>
<td>16:40</td>
<td>Beam Efficiency of Beam-Type Wireless Power Transfer via Radio Wave with Phased Array Naoki Shinohara, Kyoto University, Japan</td>
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<tr>
<td>17:25</td>
<td>Optimization of WPT Systems Transmitting Digitally Modulated Signals and other Waveforms with Time-Varying Envelope Apostolos Georgiadis and Bruno Franciscatto, CTTIC, Barcelona, Spain and Drayson Technologies, UK</td>
</tr>
<tr>
<td>18:05</td>
<td>Open Discussion and Concluding Remarks</td>
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WM05
Microwave Passive and Active Devices with Integrated Filtering Functions

Abstract
Over the last few years, there has been some exciting work reported on integrating filtering functions in various passive, active components and antennas. Many novel circuit concepts and co-design techniques have been demonstrated, such as co-designed amplifiers and filters, integrated filter-antennas, filtering power dividers, couplers and all-resonator-based multiplexers with resonant junctions etc. Traditionally filters are designed independently assuming 50 ohm matching interfaces and interconnected with other RF components. However, using the integration approach, the interfaces can be entirely eliminated and the associated mismatching and performance degradation issues can be avoided. Additionally, the integration of circuit functions could lead to significant reduction of the circuit footprint.

It is not just about close proximity of two components. To realise embedded filtering functions, various integration schemes have been demonstrated. For passive components such as dividers and couplers, the transmission lines can be replaced with resonators or signal-interference filtering sections. For multiplexers, the signal distribution and matching networks can be replaced with one or multiple resonator-junctions. In antennas, the resonant radiating element can be utilised to form one resonant pole in a filter. In active components, the filter and amplifier can be co-designed and the matching network can be implemented using resonators.

This workshop will present the recent development of new circuit concepts, design methods and implementation techniques in this area. The speakers will outline the application potentials, design challenges and solutions. This will allow the audience to explore the opportunities presented by this emerging circuit technology.

Programme

09:00 - 09:10 Welcome
09:10 - 09:40 Co-Design of High-Q Tuneable Filters with Active Devices
   D. Peroulis, Purdue University, West Lafayette, IN, USA
09:40 - 10:10 Integrated Filtering Power Dividers, Antennas and Arrays
   Y. Wang, University of Greenwich, UK; S. Gao, University of Kent, UK
10:10 - 10:40 Compact Power Distributing Devices and Power Amplifiers with Integrated Filtering Response
   X. Zhang, South China University of Technology, Guangzhou, China
10:40 - 11:20 Coffee Break
11:20 - 11:50 Waveguide Components Based on all Coupled Resonators
   X. Shang, M. J. Lancaster, University of Birmingham, UK
11:50 - 12:20 Single/Multi-Band Power-Distribution and Impedance-Transformation Planar Circuits with Added Static and Reconfigurable Bandpass Filtering Functionality
   R. Gomez-Garcia, University of Alcala, Madrid, Spain; D. Psychogiou and D. Peroulis, Purdue University, West Lafayette, IN, USA
12:20 - 12:50 Synthesis Techniques for Multiplexers and Multiport Selective Networks
   G. Macchiarella, Politecnico di Milano, Italy
12:50 - 13:00 Open Discussion and Concluding Remarks
Current and Future Use of Spectrum by PMSE - 3rd PMSE Workshop at EuMW

Organisers:
Georg Fischer, University of Erlangen-Nürnberg, Germany
Matthias Fehr, Co-President APWPT, Germany
Alan March, Co-President APWPT, United Kingdom

Abstract
PMSE (Program Making and Special Events) equipment has become, in particular, a fundamental element of our daily cultural life and wireless systems for audio, video and effect control are now essential tools for modern content production. They are employed in journalistic news coverage, sports events, theatres, by educational and cultural institutions, trade fairs, film productions, live music events, conference-centres, churches, sports clubs, etc.

PMSE is facing dramatic changes in its spectrum allocations worldwide and its coordination with other wireless services. On the other hand PMSE use and requirements regarding link availability, latency and quality are ever increasing. New techniques for spectrum management and transmission schemes are discussed in standardisation and regulation to meet these challenges.

In this workshop we would like to discuss with the participants the various types of PMSE applications, their spectrum use and impact of currently foreseeable changes in Radio Spectrum allocations. What decisions need to be taken at both a European and national level?

PMSE’s current status and its future outlook is discussed. The WS will start with an analysis of WRC-15 outcome on spectrum assignments for PMSE. As PMSE equipment is typically carried on body, a detailed look at the body effect will be taken. Results on absorption are needed for calculation of protection and interference levels. Studies on new spectra for compensation of lost spectrum at UHF will be presented. The driving forces behind increase of communications and fundamental limitations to consider from information theory perspective are discussed.

New PMSE technologies, i.e. the cognitive radio approach, were studied in industry and standards to ensure a high availability of PMSE links in the future. We discuss the advantages and possible limitations of such new PMSE technologies.

In the following we will also have a look at the socioeconomic benefit generated by the cultural and creative industry relying on PMSE.

The workshop will contain several panel rounds to allow for interactive discussion with the audience. A warm welcome to join our discussions!

Programme
Get Together will start 30 minutes ahead of official WS start
09:00 - 09:15 Welcome and Brief Introduction in the WS
Alan March, APWPT Co-President, UK

I. The Application PMSE
09:15 - 09:35 Short Introduction to PMSE
Norbert Hilbich, APWPT, Germany

II. PMSE as an Object of Science, Study Groups and Manufacturers
09:35 - 09:55 Outcome of WRC-15, Consequences for PMSE in international Working Groups and the possible Harmonisation Process(es)
Matthias Fehr, Co-President APWPT, Germany
09:55 - 10:20 PMSE Body Effect and Outlook for PMSE Operation at Higher Frequencies
Dr Ivica Stevanovic, BAKOM (Swiss federal authorities), Switzerland
10:20 - 10:40 How to Measure PMSE Live Spectrum Use?
Matthias Fehr, DKE AK731.0.8 in DIN and VDE, Germany, Andy Lillywhite
10:40 - 11:20 Coffee Break
11:20 - 11:40 The Suitability of Aircraft and Satellite Spectrum to Share with PMSE
Vaughan John, OFCOM, United Kingdom
11:40 - 12:00 Result of Spectrum Activities of ETSI and CEPT for Audio and Video PMSE
Brian Copsey, ASP and Chairman ETSI TG17WG3, UK

III. Effect of Changes
12:00 - 12:30 Analysis of Changes in PMSE spectrum - our Prediction for PMSE, operated under changed Conditions
Georg Fischer, University of Nuernberg-Erlangen, Germany
12:30 - 13:00 Economic Value of the Culture and Creative Industry (in United Kingdom)
Peter Roberts, BEIRG, United Kingdom
13:00 - 14:20 Lunch Break
14:20 - 15:00 Panel Discussion: Changes in PMSE Spectrum their Impact on Culture and Creative Segment
Can national PMSE regulation entirely support PMSE equipment user requirements in the future?

IV. Practical Needs
15:00 - 15:50 Discussion on Advantages of new PMSE Technologies and their possible Limitations
Wolfgang Bilz, Vice-President of APWPT, Germany
16:00 - 16:40 Coffee Break
16:40 - 17:30 Panel Discussion
Changes in PMSE spectrum allocations their impact on Cultural and Creative Segments.
17:30 - 17:40 Closing Remarks
Alan March, APWPT Co-President, United Kingdom
17:40 - 18:20 Meet the Presenter
WM07
New Developments for Satellite Communications on the Move

Organisers:
Patrick Schuh, Airbus Defence and Space
Arne Jacob, Hamburg University of Technology
Fabrizio De Paolis, European Space Agency, ECSAT, United Kingdom
David Seguin, European Space Agency, ESTEC, The Netherlands

Abstract
This workshop will focus on the various technology and product aspects associated with the advancement of RF/antenna systems for satellite communication on moving platforms (SatCom-on-the-move, SOTM). The workshop consists of two parts.

Part 1 will be aimed to provide a broad scope of the technologies for these new systems. Today and in future there will be an increasing demand for datalinks on moving platforms (“Internet-Everywhere”). New semiconductor technology (especially SiGe) and system concepts are key enablers for new planar antennas. Phased arrays play a major role in modern systems and include just about every aspect associated with the microwave community. Recently there were many new advancements in this field. Part 1 presentations have their focus on the MMIC and/or antenna design.

The SOTM market is booming especially in the area of Aeronautical applications, to which Part 2 is dedicated. Players like Viasat, Panasonic, Inmarsat, and many others are offering, or planning to offer, satellite based solutions for providing connectivity to airline passengers. Furthermore, there is an increasing interest towards Remotely Piloted Aircrafts (RPAs) relying on satellite communication. In this context, microwave component and system manufacturers are investing significant amounts of R&D resources in order to increase their competitiveness in the SatCom industry. Part 2 presentations will offer an overview of the different challenges to be faced by the microwave community.

Programme
09:00 - 09:10 Welcome and Introduction to Part 1
Patrick Schuh, Airbus DS Electronics and Border Security, Germany

09:10 - 09:40 Active Multiple Feed per Beam SatCom Antennas with GaN SSPA at K-Band
Arne Jacob, Hamburg University of Technology, Germany

09:40 - 10.10 Highly Integrated 20GHz/30GHz QFN Packaged ICs for Low-Cost SatCom AESAs
David Corman, Ian Gresham, Anokiwave, USA

10:10 - 10.40 Wide-Angle Scanning Phased Array Antennas at Ka-Band
Tobias Chaloun, C. Waldschmidt, W. Menzel, F. Tabarani, H. Schumacher, University of Ulm, Germany

10:40 - 11:20 Coffee Break

11:20 - 11.50 Modular Panel Array for SatCom-on-the-Move Applications
Patrick Schuh, B. Schweizer, Th. Mueller, A. Mueller, M. Boeck, Airbus DS Electronics and Border Security, Germany

11:50 - 12.20 Techniques and Technologies for SatCom Antenna Systems
Frank van Vliet, S. Monni, M. van Wanum, R. Bolt, TNO, The Netherlands

12:20 - 12.50 Electronically Liquid Crystal-Based Beamsteering Antennas for SatCom-Applications
M. Jost, C. Weickhmann, O. H. Karabey, H. Maune, R. Jakoby, Technical University of Darmstadt, Germany

12:50 - 13.00 Discussion and Concluding remarks for Part 1

13:00 - 14:20 Lunch Break

14:20 - 14:30 Welcome and Introduction to Part 2
Fabrizio De Paolis, European Space Agency, ECSAT, UK

14:30 - 14:50 Overview of SOTM Aeronautical Terminal Development at ViaSat.
Ferdinando Tiezzi, ViaSat Antenna Systems SA, Switzerland

Kim Gram, Cobham SatCom, Denmark

15:10 - 15:30 Integrating Microwave Components into the Wings of a Remotely Piloted Aircraft.
Joseph Barnard, Barnard Microsystems Ltd, UK

15:30 - 16.00 An Integrated Simulation Approach for SATCOM Phased Array Design.
Marc Rütschlin, CST - Computer Simulation Technology, UK

16:00 - 16:40 Coffee Break

16:40 - 17:00 Why Mechanically Scanned Antennas Have to Cope with a New Generation of Low Profile Aeronautical Terminals?
Raimondo Lo Forti, Space Engineering SpA (Airbus DS group), Italy

17:00 - 17:20 GaN Based, Passively Cooled L-Band SSPA for Avionics.
Suat Ayoz, Honeywell, Czech Republic

Anding Zhu, University College Dublin, Ireland

17:40 - 18:00 Millimetre-Wave Technologies for Next Generation Mobile Terminals.
George Goussetis, Heriot-Watt University, UK

18:00 - 18:20 Open Discussion and Concluding Remarks
all the steps comprising the design of a TWT from the synthesis of the requirements available design tools. The attendees will be invited in an interactive discussion on these blocks, the course will present a practical perspective of the application of blocks with focus on slow wave structures. Then, to facilitate the comprehension, the course will then address the basic principles of operation of the main functional building blocks with focus on high frequency space applications. It will start providing a summary of the main applications and related requirements impacting the amplifier design and will also cover the very recent advancement in CMOS-based mm-wave smart RFICs for 5G applications (including wireless comm, biomedical, IoT, energy harvesting and wireless power transfer) feasible and cost-effective. This very timely workshop will feature a range of presentations and will provide a comprehensive overview and understanding on important recent progress and state-of-the-art achievements in 3D/multilayer MCM technologies, including using additive printing (including Aerosol Jet and 3D printing) and subtractive techniques. The presentations will cover from advanced technology and material development to circuit and subsystem realization (including 5G E-band) for challenging microwave and mm-wave applications. The workshop will provide attendees a clear overview of the current and relevant research trends worldwide, in the field of multilayer/3D MCM (LTCC, LCP & IPD) and printing technologies. The workshop will also discuss in detail the major challenges, such as multifunction packaging, energy harvesting/transfer topologies and techniques, flexible platform and morphing/oriagami-based shape changing modules. It will also cover the very recent advancement in CMOS-based mm-wave smart RFICs for 5G nodes, 3D/2.5D MMICs, and the relative merits and application space for various techniques.

**Organisers:**
Claudio Paoloni, Lancaster University
All A Rezaadah, University of Manchester, UK

**Abstract**
In parallel with military applications, recently, the commercial applications of millimetre-wave (mm-wave) frequency bands are growing rapidly, starting from high-speed wireless to radars and medical imaging and sensing. In a mm-wave system, interconnecting parasitics make a circuit/system assembly more complex and costlier than MMIC/MMIC. Multilayer/3D Multi-Chip-Module (MCM) and System-on-Packa

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**WM08**
**Advances in Millimetre-Wave 3D Printing and MCM Technologies**

**Organisers:**
Kamal K Samanta, AMWt Ltd, UK
All A Rezaadah, University of Manchester, UK

**Abstract**
In parallel with military applications, recently, the commercial applications of millimetre-wave (mm-wave) frequency bands are growing rapidly, starting from high-speed wireless to radars and medical imaging and sensing. In a mm-wave system, interconnecting parasitics make a circuit/system assembly more complex and costlier than MMIC/MMIC. Multilayer/3D Multi-Chip-Module (MCM) and System-on-Packa

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**SCM01**
**The Basics of Travelling Wave Tube Amplifiers**

**Organisers:**
Roberto Dionisio, European Space Agency
Claudio Paoloni, Lancaster University

**Abstract**
Advanced RF/microwave applications demand power amplifiers with ever greater linear power in conjunction with high efficiency and bandwidth at a low cost. As a result, power amplifiers are considered as the most critical and expensive component in a RF-front module, like satellite communication systems and transponders, RADAR transmitters, EMC tester, jammers, etc.

So far solid state electronics is not able to respond to this quest, especially when tens of Watts in the millimetre-wave range are required. Travelling wave tube amplifiers (TWTs) are predicted to remain the only solution for high frequency, wide band and high power amplification in the near future. However, TWTs are “obscure” components for the vast majority of microwave designers.

The Short Course on The Basics of Travelling Wave Tube Amplifiers is conceived to give the attendees understanding of the latest stat-of-the-art TWTs operation with focus on high frequency space applications. It will start providing a summary of the main applications and related requirements impacting the amplifier design and will then address the basic principles of operation of the main functional building blocks with focus on slow wave structures. Then, to facilitate the comprehension of these blocks, the course will present a practical perspective of the application of available design tools. The attendees will be invited in an interactive discussion on all the steps comprising the design of a TWT from the synthesis of the requirements up to the performance verification.
Workshops and Short Courses - Tuesday

WTu01
The Application of Automotive Radar - the Further Development Towards Safety Features

Organisers:
Holger H. Meinel, Independent automotive Radar Expert
Juergen Dickmann, Daimler AG, Ulm, Germany

Abstract
Automotive radar has been on the road for several decades. 77GHz LRR and 24 GHz SRR units are produced and installed in millions these days. Even smaller cars are radar equipped today – the democratization process has already taken place (Starting with the introduction of CPA 2.0 at MB in 2012). Until recently automotive radar was employed for increased driving comfort, now a paradigm change has occurred and it is used to enhance the safety of driving – to reduce the number of fatalities in road traffic. The changing requirements from detection and ranging towards radar based environmental understanding for highly automated and autonomous driving are deduced. The traditional segmentation in driving, manoeuvring and parking tasks vanishes at the driver less stage. Situation assessment and trajectory/manoeuver planning needs to operate in another way: fast situational up-date, motion prediction of all kinds of dynamic objects, object dimension, ego-motion estimation, (self)-localisation and more semantic/classification information, which allows to put the static and the dynamic world into correlation and context with each other is mandatory. Furthermore, car construction will be changing from passive to active safety in the future. These developments, how they are implemented and how to foster them will be discussed in this workshop.

And – do not forget - radar is only one possible sensor, besides cameras and LIDAR, if we look into the future – to ADAS and autonomous driving. However, due to its very high weather independency radar has to be the backbone.

Programme
14:20 - 14:30 Welcome and Introduction
14:30 - 15:00 Automotive Radar: What to Develop to Meet Future Application
Juergen Dickmann, Daimler AG, Ulm, Germany
15:00 - 15:30 High-Resolution Automotive Radars for Safety Features and Automated Driving Function
Martin Kunert, Robert Bosch GmbH, Leonberg, Germany
15:30 - 16:00 The Evolution From CPA 2.0 to CPA 3.0
Florian Baumgartner, Daimler AG, Sindelfingen, Germany
16:00 - 16:40 Coffee Break
16:40 - 17:10 Sensor Fusion - Radar and Lidar Combined
Peter Brosseit, Daimler AG, Ulm, Germany
17:10 - 17:40 Towards a Combined Real and Virtual Test Strategy for Radar Based Functions with Respect to ISO 26262 Road Vehicle - Functional Safety
Stefan-Alexander Scheider, University of Applied Science, Kempten, Germany
17:40 - 18:10 Diffusion or Non-Diffusion of Autonomous Driving - that is the Question. The “Step-By-Step” Approach to Foster the Acceptance in our Modern Society
Bela Peterson, Proton Motor Fuel Cell GmbH and Heiko Seif, Munich Business School, Germany
18:10 - 18:20 Open Discussion and Concluding Remarks

WTu02
Radar Imaging - VHF to THz

Organisers:
Motoyuki Sato, Tohoku University

Abstract
Imaging radar technology is expanding rapidly. Synthetic Aperture Radar (SAR) is one of the leading technologies, and has been established and be used in many practical applications. Recently, the imaging radar technology is applied in different frequency ranges, which include not only microwave and millimetre wave, but Terahertz and low frequency below 1GHz. At the same time, near range imaging has been introduced in many advanced applications. In this workshop, we plan to give tutorials on the basis of Synthetic Aperture Radar, and Real Aperture Radar, which include imaging algorithm and hardware configuration. SAR technologies have been very successfully used in space borne and airborne systems. Generally these are far-range SAR using microwave frequency. We start the workshop from the advanced and distributed SAR and INSAR imaging. Then we introduce applications in Radar imaging in the frequency range of VHF to Terahertz. We also focus on near range imaging. The applications will include environmental monitoring, radar sensing for safety and security.

Programme
14:20 - 14:25 Welcome
14:25 - 15:05 Advanced and Distributed SAR Imaging Techniques
Pierfrancesco Lombardi, University of Rome "La Sapienza", Italy
15:05 - 15:45 Advanced and Distributed ISAR Imaging Techniques
Debora Pastina, University of Rome "La Sapienza", Italy
15:45 - 16:00 Near Range SAR
Motoyuki Sato, Tohoku University, Japan
16:00 - 16:40 Coffee Break
16:40 - 16:55 GPR and SAR Imaging
Motoyuki Sato, Tohoku University, Japan
16:55 - 17:30 Real - Aperture UWB Imaging
Alex Yarovoy, Delft University of Technology
17:30 - 18:10 mmW and Terahertz Technology
Dirk Nuesler, Fraunhofer HFR, Germany
18:10 - 18:20 Open Discussion and Concluding Remarks
WW01
Highly-Integrated Millimetre-Wave Systems for Small-Cell Backhaul Communication Applications

Organisers:
Dr. Vadim Issakov infineon Technologies, Neubiberg, Germany

Abstract
The smartphone revolution has led to a growing demand in mobile data traffic which subsequently has resulted in increased throughput per user. The high mobile data requirements have led to the deployment of advanced 4G Long Term Evolution (LTE) networks by the mobile network operators and this is expected to grow further in the coming years with the introduction of the 5G standard. This will provide users with much higher data rates which will increase the data traffic drastically. The increasing data rate puts an enormous burden on the network operator’s backhaul networks. The bulk of today’s base-station infrastructure is not ready to support the required high data throughput using the existing microwave backhaul systems. Though optical fibre based backhaul networks can handle a huge data throughput, they are faced with the challenge of easy and cost-effective deployment. Millimetre-wave frequencies offer additional bandwidth required for high throughput requirements of future networks. E-band (71-76 and 81-86 GHz) provides up to 10 GHz of bandwidth. Additionally, in dense metropolitan area 9 GHz bandwidth in the V-band (57–66 GHz) can be used for small-cell backhaul applications.

The workshop will discuss the application and implementation of mm-wave systems for communications. Five speakers will present different aspects of mm-wave system requirements and circuit design considerations: top level overview of the 5G and backhaul applications; state of the art and beyond state of the art realization of highly integrated transceivers in advanced SiGe and CMOS technologies. Additionally, an outlook into the future mm-wave bands for backhaul communications will be given. A panel organised at the end will discuss issues collected during the talks.

Programme

09:00 - 09:10 Welcome
09:10 - 09:55 The Trends and Challenge of Microwave/Millimetre-wave in Future 5G Wireless Communication Networks
Renato Lombardi, Huawei Technologies, Milan Microwave Competence Center, Milan, Italy
09:55 - 10:40 Circuits and System Architectures for 100+Gb/s Wireless Backhaul at W-, D- and J-Bands
Sorin P. Voinigescu and Stefan Shopov, ECE Department, University of Toronto
10:40 - 11:20 Coffee Break
11:20 - 11:50 Modular 60-GHz Beamforming Transceiver in 130-nm BiCMOS for Scalable 5G Backhaul Solutions
Dietmar Kissinger, IHP, Frankfurt Oder, Germany
11:50 - 12:20 Millimetre-wave CMOS circuits for 5G backhaul and access
Wim van Thillo, imec, Leuven, Belgium
12:20 - 12:50 A V- and E-Band Single-Chip Packaged Transceiver for small-cell Backhaul Applications
Saverio Trotta, Samo Vehovc and Vadim Issakov Infineon Technologies, Neubiberg, Germany
12:50 - 13:00 Open Discussion and Concluding Remarks
WW02  
Trends in CMOS RF ICs

Organisers:
Robert Bogdan Staszewski, University College Dublin, Ireland  
Gernot Hueber, Affiliation: NXP Semiconductors, Austria

Abstract
With the advent of nano-scale CMOS technology, exciting new developments have recently taken place in the field of RF and mm-wave transmitters, receivers and frequency synthesizers. The low-voltage, fast speed, fine feature-size and low cost of the new technology have forever changed the way we design circuits, architectures and systems. Not only have the RF/mm-wave circuits taken different shapes from what has been taught in textbooks, but also their integration with digital processors have enabled new possibilities for digital assistance, offering autonomous built-in self-testing and self-calibration. This workshop gives an overview and samples of such latest developments.

WW03  
Towards 0.7 Terahertz SiGe Hetero-Junction Bipolar Transistor Technology: the DOTSEVEN Project

Organisers:
Rudolf Lachner, Infineon Technologies AG, Neubiberg, Germany  
Ullrich Pfeiffer, Bergische Universität Wuppertal, Germany  
Andreas Stelzer, Johannes Kepler University of Linz, Austria

Abstract
Europe owes its leading position in silicon-based mm-wave and terahertz technology and applications mainly to the outcome of very successful, publically funded, multi-national R&D projects like DOTFIVE, RF2THz and DOTSEVEN which pushed the high-frequency performance and integration capabilities of Silicon-Germanium Heterojunction Bipolar and BiCMOS technologies to new, undreamt frontiers. DOTSEVEN, the last project in this row which ended in June 2016 after almost 4 years, had the very ambitious goal to develop a Silicon-Germanium (SiGe) heterojunction bipolar transistor (HBT) technology with an intrinsic cut-off frequency (fmax) of up to 700 GHz. Special attention was paid to clearly demonstrate in parallel its manufacturability and suitability for CMOS integration. A large part of the effort was put into the hardware demonstration of the capabilities and benefits of such a technology by benchmark circuits and advanced system applications in the 0.1 to 1 THz range like THz imaging and sensing, wireless Tb/s communications and mm Wave radar. Technology and circuit development were supported by extensive, physics-based device and circuit modelling activities. The workshop will give a condensed but nevertheless comprehensive overview of the final results of the DOTSEVEN project. The presentations will be given by the key researchers and engineers of the project, who are also well known and recognised experts in their fields.
**Abstract**

Constant striving towards higher data rates in modern communication systems and the foreseen revolution related to the forthcoming 5G mobile communications are laying the ground for an explosion of the millimetre-wave radio market. The reason? Frequency bands are wider, less overcrowded, and cheaper. Modulation schemes can be relaxed, while very directive antennas can be exploited to realize radio hops of several hundred meters.

On the other hand, the design of all the involved high frequency components is more demanding. The power amplifier, specifically, is a fundamental block of the transmitter for its impact on the overall performance of the entire system and hence poses severe challenges to the designer.

This workshop addresses the peculiar issues involved in the design of power amplifiers in this high-frequency scenario and compares them to the ones confronted with in the traditional microwave bands.

Experts coming from leading groups actively involved in mm-wave PA design will describe and comment upon solutions of choice and real-world examples, both in compound semiconductors (GaAs and GaN) and in Si-CMOS.

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**Programme**

- **14:20 - 14:50** Introduction  
  Prof. Marco Pirola - Politecnico di Torino - Italy

- **14:50 - 15:25** PA Requisites for mm-Wave Backhauling: Illusion or Reality?  
  Dr. Alessandro Fonte - SIAE Microelettronica - Italy

- **15:25 - 16:00** High Efficiency Millimetre-Wave Power Amplifiers for Wireless Communications  
  Prof. Anh-Vu Pham - University of California, Davis - US

- **16:00 - 16:40** Coffee Break

- **16:40 - 17:10** MM-wave MMIC power amplifiers and linearizers  
  Dr. Mattias Ferndahl - Gotmic - Sweden

- **17:10 - 17:40** Power Amplifier Design for 100+ GHz Backhaul Applications  
  Dr. Thomas Emanuelsson - Ericsson Research, Adj Prof at Chalmers university of Technology - Sweden

- **17:40 - 18:10** Wideband CMOS PA design at mm-wave: challenges and case studies  
  Dr. Matteo Bassi - Università di Pavia - Italy

- **18:10 - 18:20** Open discussion and concluding remarks

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**Abstract**

As the market of GaN power HEMTs is growing rapidly, various kinds of technical problems of improving RF performance, thermal conductivity, reliability, cost, etc. are being discussed in major conferences. This workshop introduces and discusses recent advances in GaN HEMTs for microwave applications while focusing on thermal management and low-cost approaches from a viewpoint of actual product use. One reason is that the excellent RF power potential of GaN HEMTs is often restricted by thermal problems. Another reason is that a low-cost approach is one of the most significant key issues in making GaN HEMTs more popular in microwave markets. For these problems, a GaN-on-diamond structure is one of the most promising candidates to solve thermal problems. Plastic packaging techniques, the use of GaN-on-Si HEMTs, and GaN- and GaAs-based hybrid approaches are very effective in reducing the GaN HEMT production cost.

It may seem that such a theme similar to the above topics has already been discussed to date in some conferences. However, it is of great value to GaN PA designers, especially beginners or less-experienced designers, because this workshop allows the attendees to learn and understand the hottest topics and the latest results related to GaN RF power HEMTs at the same time. In addition, the number of GaN PA designers is currently increasing in manufacturers as well as R&D institutes and universities.

In this workshop, these topics, in addition to the fundamentals of GaN HEMT, will be presented by world-leading experts.
WTH01
Waveform Engineering in Power Amplifier Design

Organisers:
Roberto Quaglia, Cardiff University

Abstract
Waveform engineering is an old-school tool for the design of power amplifiers aiming to reach high efficiency. However, recent discoveries in the field of continuous modes, together with the need of combining high efficiency with bandwidth and linearity, have re-boosted the interest of the microwave community on this topic, leading to a substantial number of publications in the field.

This workshop provides an overview on waveform engineering techniques in the design of power amplifiers, and addresses specific hot questions from the microwave community. How do I realize in practice a matching network that engineers the waveform? How does the picture change when the device is saturated? How do I apply waveform engineering to Doherty power amplifiers? Can I simplify my waveform measurements using low frequency approximation?

Recognised experts in the field will provide answers, hints and suggestions on these widely discussed topics.

An appropriate amount of time will be given at the end of each talk to allow interaction between the audience and the presenters. A final 30 minutes round table involving all the presenters will be a further occasion to encourage the exchange of ideas.

SCTh01
Fundamentals of Microwave PA Design

Organisers:
Ali A Rezazadeh, University of Manchester, UK
Franco Giannini, Universita` di Roma `Tor Vergata`, Italy

Abstract
Semiconductor power amplifiers are key components of the circuitry that drives radio frequency and microwave transmission and have received a great deal of attention and development effort over the last decade. This short course aims to provide a comprehensive overview of all aspects of fundamental semiconductor microwave power amplifier design. The course is an introductory one, aimed at graduate engineers who have moved into the field of RF design.

This short course features a range of presentations and will provide a comprehensive overview and basic understanding on recent important progress and novel state-of-the-art achievements in semiconductor power amplifiers. It will include fundamental concepts and state-of-the-art results on actual designs of a range of semiconductor power amplifiers using existing foundries. The presentations will also cover a variety of advanced topics, and will provide the attendees with a clear overview of the main streams of current and important research trends worldwide in this field. The short course will also focus on the major challenges, such as various non-linearity issues and how to address these in amplifier design. Very recent advances in semiconductor amplifiers and their applications will also be covered.
WF01
Art1St: Architecting Smart Internet-of-Things Networks for Smart Cities

Organisers:
Syed Ali Raza Zaidi, University of Leeds
Muhammad Ali Imran, University of Surrey
Mischa Dohler, Kings College London
Des McLernon, University of Leeds
Maryam Haifeez, University of Leeds
Ian Robertson, University of Leeds

Abstract
The term ‘internet-of-things’ (IoT) was coined by Kevin Ashton in 1999. The central idea was to empower everyday objects with internet connectivity thus enabling pervasive and autonomous communication. The foundation of IoT is based on Weiser’s vision of profound software/hardware technologies that weave themselves into fabric of everyday life such that they become indistinguishable. The functionality and modalities of these technologies is distributed across a variety of interconnected objects. The inter-connectivity of these objects is pivotal as the collective intelligence of the IoT network emerges from simple object level interactions. In turn, such a collective intelligence can be credited with driving significant innovations in the context of various applications under the umbrella of smart homes and cities.

While IoT communication networks will be a corner stone for next generation connected smart cities, a clean slate and smart design is required for these networks. The aim of this workshop is to bring together leading industrial and academic researchers to discuss design issues, challenges and opportunities in the area of IoT communication networks. The workshop program is designed to cross-fertilize research ideas with microwave community. The distinguished invited speakers will highlight specific research challenges to various verticals (transport, health, retail etc.) and will discuss fundamental horizontal design issues.

Programme
09:00 - 09:05 Welcome
09:05 - 10:40 IoT Applications Panel
09:05 - 09:30 Talk #1: The Relevance of RF to Future Health - SPHERE and Beyond
  Prof. Ian Craddock, University of Bristol & Toshiba Research Lab, Bristol, UK
09:30 - 09:55 Talk #2: oneTRANSPORT: A Real oneM2M Deployment to Reshape the Transport Sector
  Dr. Rafael Cepeda, Interdigital, UK
09:55 - 10:20 Talk #3: IoT in-the-wild: Challenges and Opportunities
  Dr. Hamed Haddadi, Queen Mary University, London, UK
10:20 - 10:40 Discussion and Q/A
10:40 - 11:20 Coffee Break
11:20 - 13:00 IoT Technologies
11:20 - 11:40 Machine-to-Machine Trust for the Internet of Everything
  Prof. Alan Marshall, University of Liverpool, Liverpool, UK
11:40 - 12:00 5G Radio Access Technologies for Enabling IoT Networks
  Dr. Maziar Nekovee, Samsung, UK
12:00 - 12:20 Real World Information Infrastructures Based on the Internet of Things
  Dr. Alex Gluhak, Digital Catapult and IoTUK, UK
12:20 - 12:40 Smart Cities in the Age of Big Data and the Internet of Things
  Dr. Payam Barnaghi, University of Surrey & 5GIC, Surrey, UK
12:40 - 13:00 IoT Research Outlook: Applications, Deployment Models and Socio-Technical Challenges
  Dr. Syed Ali Raza Zaidi, University of Leeds, UK
  Dr. Muhammad Imran, University of Surrey, UK
  Tracy Keys, Digital Economy Theme, EPSRC
  Dr. Alex Gluhak, Digital Catapult UK
  Dr. Hamed Haddadi, QMUL, UK
  Prof. Alan Marshall, University of Liverpool, UK
  Prof. Ian Craddock, Toshiba Research Lab, UK
  Dr. Rafael Cepeda, Interdigital, UK
  Dr. Maziar Nekovee, Samsung, UK
  Dr. Payam Barnaghi, University of Surrey, UK
WF02
Radar Performance in Clutter - Modelling, Simulation and Target Detection Methods

Organisers:
Simon Watts, UCL
Keith Ward, Igence Radar
Maria Greco, University of Pisa

Abstract
The workshop presents the latest advances in clutter modelling for radar and how these models are exploited in radar design and development. Most radars must contend with unwanted clutter returns in addition to those from targets of interest. The ability to characterise and model clutter in a manner that can be exploited by a radar designer is central to most phases of the life cycle of a radar, from initial concept, through design and development and up to final acceptance of a radar into service by a customer. The workshop will provide an overview of the ways in which clutter is modelled and how practical models are developed for use by radar designers. This is a continuously developing field and some of the latest results will be presented.

Clutter models are central to the development of advanced simulations of radar systems, which can be used for applications such as the development of new detection algorithms, the testing of real-time signal processing systems and interactive training systems. The exploitation of clutter models in radar system simulations will be described in the workshop. Finally, the development of detection systems for radar that are robust to all conditions relies heavily on the ability to accurately model the characteristics of targets, clutter and thermal noise. The workshop will describe the latest advances in methods for detection of targets embedded in clutter and noise.

Programme
09:00 - 09:05 Welcome
09:05 - 10:00 Radar Clutter Modelling
   Simon Watts, UCL
10:00 - 10:40 Simulation of Clutter
   Keith Ward, Igence Radar
10:40 - 11:20 Coffee Break
11:20 - 11:40 Simulation of Clutter (cont.)
   Keith Ward, Igence Radar
11:40 - 12:40 Advanced Detection Schemes
   Maria Greco, University of Pisa
12:40 - 13:00 Open Discussion and Concluding Remarks

WF03
Millimetre-Wave Technologies for 5G Mobile Networks and Short-Range Communications

Organisers:
Laurent Dussopt, CEA-LETI, France
Frédéric Gianesello, STMicroelectronics

Abstract
Millimetre-wave (mm-Wave) radio technology is seen as a key enabler for 5G wireless mobile networks and future high data-rate wireless communication systems. They will open access to the wide spectrum resources available from 10 GHz to 100 GHz and even beyond to provide multi-Gbps broadband access to mobile users, high-capacity wireless backbone links between access points/base-stations, and very high data-rate wireless solutions for short-range or long-range applications. These application fields are very active throughout the world with several significant demonstrations already done. Regarding mm-Wave applications in 5G mobile networks, standardization activities have already started in 3GPP and other standardization bodies, while first regulations are expected in 2018 at the 2018 ITU-R World Radio-communication Conference. Systems operating beyond 100 GHz are less mature and very much open to innovation using latest device and manufacturing technologies.

The workshop will include several talks by high-level experts from industry and academia who will present their vision on the role of mm-wave communications in 5G and the main needs/requirement in this domain, state-of-the-art radio and antenna realizations both below and above 100 GHz, and advanced concepts for sub-mmWave and THz communications.

Programme
09:00 - 09:10 Welcome
09:10 - 09:55 5G Mobile Communications above 6 Ghz: Timelines, Key Technologies and Recent R&D
   Maziar Nekovee, Samsung R&D, United Kingdom
09:55 - 10:40 User Exposure at Millimetre Waves: Electromagnetic and Thermal Dosimetry in V-Band
   Maxim Zhlobodov, IETR - University of Rennes 1, France
10:40 - 11:20 Coffee Break
11:20 - 12:10 Cost Effective mm-Wave System Leveraging Silicon Technology and Digital Manufacturing
   Cyril Luxey, University of Nice-Sophia Antipolis, France
   Frédéric Gianesello, STMicroelectronics, France
12:10 - 13:00 Reconfigurable millimetre-wave transmitarray antennas for backhaul applications
   Laurent Dussopt, CEA-LETI, France
13:00 - 14:20 Lunch Break
14:20 - 15:10 Hardware and System Design for Wireless Fibre in the Millimetre-Wave Band
   Amin Arbabian, Stanford University, USA
15:10 - 16:00 300 GHz Fixed Wireless Links
   Ingnmar Kaifliss, University of Stuttgart, Germany
16:00 - 16:40 Coffee Break
16:40 - 17:30 THz Point to Point Links for Back-Hauling in Future Networks
   Guillaume Ducourneau, IEMN, France
17:30 - 17:45 Open Discussion and Concluding Remarks
WF04
Fundamentals and Engineering Considerations of THz Technologies: from Devices to Applications

Organisers:
Dimitris Pavlidis, Boston University & National Science Foundation, USA
Imran Mehdi, Jet Propulsion Laboratory (JPL) USA
Javier Mateos, University of Salamanca, Spain

Abstract
THz technology development is a vibrant scientific field with new discoveries and techniques being utilized to advance the State-of-the-Art and lead to new applications with enhanced functionality. While novel material systems such as graphene have shown promise in the THz range, fully functional systems in the THz range are also becoming more common. This workshop will bring together experts from various academic and national labs to discuss the most recent advances in their respective fields and to provide insight into what the future might hold for exploration of this frequency range. It will focus on a variety of materials such as traditional III-Vs, III-Nitrides and Graphene, as well as various device concepts for efficient THz generation and detection. The operation of the components to be discussed is based on plasmonics, photoconductors, plasma waves, photomixing, Resonant Tunneling, Negative Differential Resistance. Devices such as Quantum Cascade Lasers and Self-switching Diodes will also be addressed. The Workshop is intended primarily for young scientists and engineers who are interested in learning about this emerging field, but is also useful for individuals with a more advanced understanding of related concepts. The topics addressed include fundamental and engineering considerations. The latest results in Terahertz technologies and applications will also be presented.

Programme
09:00 - 09:10 Welcome
09:10 - 09:40 THz Applications and Upcoming Space Missions
Imran Mehdi, Jet Propulsion Laboratory, Pasadena, CA, USA
09:40 - 10:10 Fundamentals and Latest Results on Nitride-Based Two- and Three-Terminal Devices for Frequencies Extending to THz
Dimitris Pavlidis, Boston University, USA
10:10 - 10:40 Planar Nanodiodes for THz Detection and Mixing
Javier Mateos, University of Salamanca, Spain
10:40 - 11:20 Coffee Break
11:20 - 11:50 THz Oscillators using Resonant Tunneling Diodes and their Functions for Various Applications
Masahiro Asada and Safumi Suzuki, Tokyo Institute of Technology, Japan
11:50 - 12:20 Rare-Earth-Doped GaAs THz Sources Driven at 1550 nm
E.R. Brown, J.R. Middendorf, and J.S. Cetnar, Wright State University, USA
12:20 - 12:50 THz Field Effect Transistor Detector Arrays for Postal Security Imaging Applications
W.Knap, D.But, A. El Fatimy, P.Buzatu, O Klimenko, N.Diakonova, Charles Coulomb Laboratory, Montpellier University & CNRS, Montpellier, France
12:50 - 13:00 Discussion
13:00 - 14:20 Lunch Break
14:20 - 14:50 Graphene-based THz optoelectronic devices
Berardi Sensale-Rodriguez, University of Utah, USA
14:50 - 15:20 High Performance THz Radiation Sources based on Plasmonic Photoconductors
Mona Jarrahi, UCLA, USA
15:20 - 15:50 Photomixing mW THz Sources
G. Ducournau, P. Latzel, F. Pavanello, E. Peytavit, M. Zaknoune, J.-F. Lampin, IEMN, Villeneuve d’Ascq, France
15:50 - 16:00 Discussion
16:00 - 16:40 Coffee Break
16:40 - 17:10 THz Optoelectronic Devices
Yanko Todorov, Stefano Barbieri, Djamal Gacemi, Maria Amanti, Angela Vasanelli and Carlo Sirtori, Université Paris-Diderot, France
17:10 - 17:40 Title TBA
Manijeh Razeghi, Northwestern University
17:40 - 18:20 Open Discussion and Concluding Remarks
Advances in GaN Power Amplifiers: Linearity, Bandwidth and Efficiency

Organisers:
Kamal K. Samanta, AMWT Ltd, UK
Bumman Kim, Pohang University of Science and Technology (POSTECH), Korea

Abstract
Emerging microwave applications demand power amplifiers (PA) with ever greater linear power, bandwidth and efficiency, yet at a low cost. The new power systems, like wireless broadcast transmitter, radars (EW), EMC tester, jammers, etc., require the latest state-of-the-art semiconductor in combination with advanced design and integration technologies to deliver optimum performance. GaN is the superior candidate to meet these requirements; since its introduction, it has been creating many records, and there is much more potential to be better understood and utilized

A GaN transistor delivers the highest level of power density, but owing to the small footprint, GaN PAs are thermally limited much below its capability. As a result, novel and efficient design and biasing technique, thermal management, selection of mode/class of operation, etc. play very crucial roles to satisfy the new generation PA requirements. An amplifier operating in Class-A favors linearity and harmonics but suffers from efficiency and thermal load. On the other hand, Class-AB struggles to meet bias stability, gain, and linearity at the same time, achieving linearization and modulation requirements with an extreme bandwidth for EMC/EW applications; meeting the bandwidth, linearity and efficiency in Doherty at high peak-to-average power ratios (PAPR) for telecom/mobile applications; and overcoming the effect of trapping/memory, raise several technical challenges to address

This very timely workshop will highlight the important recent advancements in GaN-based circuit design, linearization, and system implementation. Most importantly, the workshop will aware the participants on the critical design issues with hints, technology challenges, and the latest state-of-the-art performance in terms of power, efficiency, linearity and bandwidth, which enabling advanced industrial applications from wireless communication (including LTE and replacement of LDMOS in base stations) to ultra-wideband EMC testers and RADARs. The speakers are the experts and are the leading contributors in both industrial and academic sectors.

Programme
09:00 - 09:10 Welcome

09:10 - 09:55 Design of Highly Efficient and Linear Power Amplifiers by Generalization of the Doherty Theory
William Hallberg*, Mustafa Özen*, Kristoffer Andersson*, David Gustafsson* and Christian Fager*(Speaker).
*Chalmers University of Technology, Sweden; +Ericsson AB, Sweden

09:55 - 10:40 Doherty Amplifier Optimization Using Offset Line
Prof. Bumman Kim, University of Science and Technology (POSTECH), Korea

10:40 - 11:20 Coffee Break

11:20 - 11:50 Advanced GaN HEMT HPAs With Wider Than Decade Bandwidth
Dr. Kamal K Samanta, AMWT Ltd, UK

11:50 - 12:20 How to Truly Benefit from the Gan Performance Potential?!
Prof Leo de Vreede, Delft University of Technology, The Netherlands
Prof. Allen Katz, Linearizer Technology, Inc.; and Electrical/Computer Engineering at The College of New Jersey, USA

12:20 - 12:50 New Developments in Linearization of GaN Power Amplifiers
Prof. Allen Katz, Linearizer Technology, Inc. and Electrical/Computer Engineering at The College of New Jersey, USA

12:50 - 13:00 Open Discussion and Concluding Remarks
Duration: 09:00 to 17:30
Room: 13

WF06
Chip Packaging and System-in-Package

Organisers:
Thomas Zwick, Karlsruhe Institute of Technology
Ian Robertson, University of Leeds
Andy Longford, IMAPS UK

Abstract
Microelectronic packaging technology has advanced tremendously in recent years and microwave, millimetre-wave and terahertz systems can benefit particularly from the ability to integrate diverse active devices (Si, SiGe, GaAs, GaN, InP, etc.) and passive components into a cost-effective module. Millimetre-waves are of immense interest for 5G systems, both for wireless backhaul and for handsets, and 60 GHz band Wi-Fi modules are already available using system-in-package technology with integrated antenna arrays. This workshop will provide delegates with an understanding of a wide range of world-leading research and development that is pushing the boundaries of what can be achieved in terms of high power and high frequency packaging. This includes antenna-in-package techniques, wafer-level packaging, chip-on-chip and 3D stacking, substrate-integrated waveguides and low loss interconnects operating at frequencies up to the hundreds of GHz for wireless communications, short range radar and sensing applications.

Programme

09:00 - 09:10  Welcome
09:10 - 09:40 Packaging Approaches for Broadband Communication Systems
Arne F. Jacob, Hamburg University of Technology, Germany
09:40 - 10:10 3D System-in-Package Technology
Philippe Descamps, Laboratoire de Microélectronique et de Physique des Semiconducteurs (LaMIPS), ENSICAEN, France
10:10 - 10:40 MMIC Packaging Technologies for mm/submm-Wave Wireless Applications
Shoichi Shiba, Fujitsu Limited, Fujitsu Laboratories Ltd., Japan
10:40 - 11:20 Coffee Break
11:20 - 11.50 Industrial High-Volume Packaging for mm-Wave Transceivers
Frederic Gianesello, STMicroelectronics, France
11:50 - 12.30 3D System-on-Substrate Technology with Substrate Integrated Waveguides
Ke Wu, École Polytechnique de Montréal, Canada
12.30 - 13.00 QFN Based Packaging Concepts for Millimetre-Wave Transceivers
Thomas Zwick, Karlsruhe Institute of Technology, Germany
13:00 - 14:20 Lunch Break
14:20 - 14:50 eWLB Packaging with integrated Antenna in the mm-wave Range up to 240 GHz
Andreas Stelzer, Johannes Kepler University Linz, Austria
14:50 - 15:20 Plastic Air Cavity Packages Enable Low Cost Entry for High Frequency Applications
Andy Longford, PandA Europe & RJR technologies, UK
15:20 - 16:00 Multi-Physics Modelling of Power Devices
Peter Aaen, University of Surrey, UK
16:00 - 16:40 Coffee Break
16:40 - 17:10 EDA for Package/Circuit EM Modelling
Dave Morris, Keysight Technologies, UK
17:10 - 17:30 Open Discussion and Concluding Remarks
WF07
Compact and High Performance Millimetre-Wave and THz Sources & Systems

Organisers:
Edward Wasige, University of Glasgow
Bruce Napier, Vivid Components Ltd
Wolfgang Templ, Nokia Bell Labs
Richard Hogg, University of Glasgow

Abstract
Europe is at the forefront of developing semiconductor-based millimetre-wave (mm-wave) and terahertz (THz) electronic and photonic technology platforms to address societal challenges, such as the ever-growing volume of data for mobile devices such as phones, laptops etc. which will soon require new ultra-broadband (multi-gigabit) wireless communications to easily and effectively access data-rich content, or for machine-to-machine communications as in data centres to handle the large volumes of data. Beyond communications, mm-wave/THz technologies can underpin imaging applications as required for inspection of concealed weapons or sensing applications as required in the identification of biological samples or chemical agents. Consequently, a host of technology options have been proposed for this frequency range, but those based on advanced semiconductor microwave monolithic integrated circuits (MMICs) and on resonant tunnelling diodes (RTDs) are being actively developed.

This workshop will discuss the RTD technology being developed on iBROW (http://ibrow-project.eu), a Horizon 2020 project on front-ends for short-range multi-gigabit wireless links and microwave-photonic interfaces for seamless links to the optical fibre backbone network. The discussions will be underpinned by an industrial perspective from an end-user, especially with regards to technical specifications as well as commercial considerations for future practical mm-wave/THz systems. Latest state-of-the-art results on RTD technology by other researchers including 2 THz oscillators and on the manufacturability of low-cost tunnelling devices will also be presented. Finally, results from other European projects TWEETHER (http://tweether.eu) & M3TERA (https://m3tera.eu) will also be presented. TWEETHER is developing a travelling-wave-tube based W-band technology for a transmission hub for point to multipoint wireless distribution with high capacity, while M3TERA is developing a micromachined (silicon) platform for the heterogeneous integration of terahertz components to enable high data rate short range wireless communications.

Programme
09:00 - 09:10 Welcome
09:10 - 09:40 Perspectives for Commercialisation of RTDs in High Performance mm-Wave Transceivers
Wolfgang Templ and Andreas Pascht, Nokia Bell Labs, Germany
09:40 - 10.00 Resonant Tunnelling Diode Technology for mm-Wave and THz Applications
Edward Wasige, University of Glasgow, United Kingdom
10.00 - 10.20 Resonant Tunnelling Diode Microwave Photonics Interface for Wireless Communications
José M. L. Figueiredo, Universidade do Algarve, Portugal
10.20 - 10.40 Ultra-Broadband Rtd Based Wireless Communications
Luís Pessoa, INESC - Instituto de Engenharia de Sistemas e Computadores, Porto, Portugal
10:40 - 11:20 Coffee Break
11.20 - 11.40 Resonant-Tunneling-Diode THz Oscillators and Applications: Structures for High Frequency, High Output Power, and High Functionality
Masahiro Asada and Safumi Suzuki, Tokyo Institute of Technology, Japan
11.40 - 12.00 Low Cost Manufacturing of RTD and ASPAT Tunnel Diodes for mm-Wave/THz Applications
Mohamed Missous, University of Manchester, United Kingdom
12.00 - 12.20 H2020 TWEETHER Project for Wireless Communications at W-Band
Viktor Krozer, Goethe University of Frankfurt, Germany
12.20 - 12.40 H2020 M3TERA Project– Micromachined terahertz systems
Joachim Oberhammer, KTH Royal Institute of Technology, Sweden
12:40 - 13:00 mm-Wave/THz Technologies for Wireless Communications: What Challenges and Which Solutions? Open discussion and concluding remarks

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**Microwave and Millimetre-Wave Technologies for Medical Diagnostics and Imaging**

**Organisers:**
Panagiotis Kosmas, King’s College London, United Kingdom
Lorenzo Crocco, CNR-IREA, National Research Council of Italy, Institute for Electromagnetic Sensing of the Environment, Italy

**Abstract**

The application of microwave and mm-wave technologies for medical imaging and diagnostics is an emerging topic within the electromagnetic engineering community. Technological developments in this area have been accelerated by advancements in antenna design and fabrication, computational methods, imaging algorithms, as well as measurement techniques. In parallel to these developments, advances in hardware and increased accessibility of high-frequency technologies has paved the way to novel and very promising medical applications related to this portion of the electromagnetic spectrum.

This workshop features experts from Europe, USA, and China, who will offer the participants an up-to-date overview of recent progress and future perspectives in this field. The workshop presentations and discussions will describe microwave and mm-wave techniques, algorithms, and experiments covering:

- Medical diagnostic sensing, imaging, and monitoring
- Novel antennas and sensors for medical diagnostics
- Contrast-enhanced imaging
- Emerging applications such as communications and sensing at nanoscale

The workshop will be equally beneficial to young scientists and engineers who are interested in acquiring up to date knowledge about this emerging field, as well as academics and professionals who wish to embark on (or are already active in) this area.

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**Programme**

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<td>A Micromachined mm-Wave Skin Cancer Sensor: From Technology Development to Clinical Studies</td>
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<td>Subcutaneous Biosensors for Long-Term Continuous Health Monitoring and Management</td>
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<td>Thz Channel Characterisation and Modelling for Nano-Scale Communication Networks Aimed at Healthcare Monitoring Applications</td>
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WF09
Millimetre-Wave Transmission: Activities of the ETSI ISG MWT

Organisers:
Nader Zein, NEC Europe Ltd
Renato Lombardi, Huawei Technologies

Abstract
Microwave radio has been the main technology for many years in providing mobile backhaul and wireless transport systems and applications. With the increase in demand for capacity the use of mm-wave radio became essential in order to meet the new requirements for mobile and IP networks in the core and access. This increase in demand is estimated to grow at a much higher rate in the next 5 to 10 years to reach 1000 times the current network capacities. The role of mm-wave radio for wireless transport and wireless backhaul will become paramount in order to provide the capacity in the wireless transport network for 5G and future networks. The workshop is presented by the ETSI ISG mWT, whose members include operators, manufacturers and technology providers. The workshop will give some of the activities in the ISG mWT on future higher frequency bands (from 50 GHz up to 300 GHz) for large volume applications in: back-hauling; front-hauling to support mobile network implementation; wireless local loop; and emerging future services benefitting from high speed wireless transmission. The workshop will benefit new engineers and researchers interested in the development of the mm-wave technology and will give them insights into the future demand for mm-wave radio systems and good understanding to the real commercial applications and deployment scenarios.

Programme
09:00 - 09:10 Welcome and Opening Remark
09:10 - 09:30 Introduction and Overview of the ISG mWT
Renato Lombardi, Chair of ISG mWT and Huawei Technologies
09:30 - 10:00 Applications and Use Cases of Millimetre-Wave Transmission
Dimitris Siomos, Deutsche Telekom AG
10:00 - 10:40 V-Band Street Level Interference Analysis
Pietro Nava Huawei, Huawei technologies
10:40 - 11:20 Coffee Break
11:20 - 11:50 Global Regulations Status of the 60 and 80 GHz Bands
Jyri Putkonen, Nokia Solutions and Networks GmbH & Co. KG
11:50 - 12:20 Field Proven Experience of Millimetre-Wave Transmission
Jonas Hansryd, Ericsson Telefonaktiebolaget LM
12:20 - 12:40 Above 90GHz Spectrum Allocation and Applications Scenarios
Nader Zein, NEC Europe Ltd
12:40 - 13:00 Open Discussion and Concluding Remarks

WF10
Bistatic and Multistatic Radar

Organisers:
Mike Cherniakov, University of Birmingham
Pierfrancesco Lombardo, University of Rome La Sapienza
Debora Pastina, University of Rome La Sapienza
Marco Martorella, University of Pisa
Marina Gashinova, University of Birmingham
Chris Baker, Aveillant Ltd.

Abstract
Bistatic, Multistatic and Netted Radars represent a vibrant research area of modern radar and remote sensing technology. Over the last two decades this technology has been a focus of the worldwide radar community, with great but still not fully discovered potential for target detection, tracking and automatic recognition, as well as wide area surveillance and imaging. The workshop starts by introducing the basics of bistatic/MIMO radar geometries and waveforms, and continues with specific problems of these radars, including real time observation, SAR and GMT modes. Automatic target classification is currently one of the most complex problems of radar technology and a possible solution is in the use of Inverse SAR and specifically Multistatic ISAR. ISAR from the basic to state-of-the-art stage will be discussed during the workshop and Mono and Multi Static ISAR performance will be compared. Since the 1970’s, stealth target detection is considered as the vital problem for defence and Forward Scatter Radar (FSR) is perhaps the only reliable solution for this. Various aspects of FSR will be considered during the workshop. Finally, radar networks, enabling large areas to be covered, are discussed. By this technology a more comprehensive and integrated picture of, for example, aircraft can be created, able to cope with rapidly increasing quantities of air traffic.

Programme
14:20 - 14:30 Welcome
14:30 - 15:15 Bistatic, Multistatic and MIMO Radar
Pierfrancesco Lombardo and Debora Pastina
University of Rome La Sapienza, Italy
15:15 - 16:00 Bistatic/Multistatic Inverse SAR
Marco Martorella, University of Pisa, Italy
16:00 - 16:40 Coffee Break
16:40 - 17:25 Forward Scatter Radar
Marina Gashinova, University of Birmingham, UK
17:25 - 18:10 National Networked Radar
Christopher Baker, Aveillant Ltd, UK
18:10 - 18:20 Open Discussion and Concluding Remarks
WF11
Digital Beamforming Space-Borne Synthetic Aperture Radar

Organisers:
Steven Gao, University of Kent, Canterbury, UK,
Luigi Boccia, University of Calabria, Italy
Anja Bölöcke, Silicon Radars
Tobias Rommel, Microwaves and Radar Institute, German Aerospace Center (DLR)

Abstract
Digital beamforming (DBF) synthetic aperture radar (SAR) is considered as the solution to the next-generation space-borne earth observation. This workshop will present the most recent results of the European consortium project (funded by EU FP7) titled as DIFFERENT (Digital beam Forming For low-cost multi-static space-bornE syNthetic aperTure radars). This is an ambitious multi-disciplinary project aiming to develop the next-generation high-performance low-cost digital beamforming space-borne multi-static synthetic aperture radars for small-satellite constellations in Europe. Speakers will consist of leading researchers from European Space Agency and the project consortium including German Aerospace Centre (DLR), Germany; University of Kent, UK; Silicon Radars, Germany; University of Calabria, Italy; IHP, Germany; EVATRONIX SA, Poland; and ISIS - Innovative Solutions In Space BV, Netherlands. The workshop will focus on the current trends of DBF-SAR systems for Earth Observation, the techniques required for the DBF-SAR instrument, the antennas and arrays for SAR, LNC chips design, BiCMOS technologies, the algorithms for DBF techniques, and integration techniques. The latest results in the project DIFFERENT regarding various sub-subsystems of SAR-DBF will be presented.

Programme
14:20 - 14:30 Welcome
14:30 - 15:00 DBF SAR Systems for Earth Observation and Current Trends
Dr Michael Ludwig, ESTEC, European Space Agency, Netherlands
15:00 - 15:20 Digital Beam-Forming Techniques for a DIFFERENT Synthetic Aperture Radar Instrument
Dr Tobias Rommel, Microwaves and Radar Institute, German Aerospace Center (DLR)
15:20 - 15:40 Antennas for Space-Borne Synthetic Aperture Radars
Professor Steven Gao, University of Kent, Canterbury, UK
15:40 - 16:00 Low Noise Converter Chips for Dual Band Ka/X Space-Borne Synthetic Aperture Radar
Dr Srdjan Glisic, Silicon Radar, Frankfurt Oder, Germany
16:00 - 16:40 Coffee Break
16:40 - 17:00 Integration Techniques for Digital Beam Forming Synthetic Aperture Radars
Professor Luigi Boccia, University of Calabria, Italy
17:00 - 17:20 RF BiCMOS Technologies for Space Applications
Dr Miles Krstic, IHP, Frankfurt (Oder), Germany
17:20 - 17:40 RF Digital Beamforming for Space-Borne Radars
Dr Piotr Penkala, Evatronics, Poland
17:40 - 18:00 XXa-Band SAR System Accommodation on a Small Satellite and First Payload Demonstrator Integration
Dr Wouter Jan Ubbels, Innovative Solutions in Space B.V
18:00 - 18:20 Open Discussion and Concluding Remarks
**Abstract**

The vast majority of high performance radars developed in the last two decades are based on electronic scanned arrays (ESA). Although their design and performance were understood and published in the early part of the 20th century, they only found wide application when government investment and consumer electronics provided the technology base to develop and field low cost high performance systems.

The objective of this short course is to provide an introduction to the theory and application of electronic scanned arrays. The focus will be antenna hardware and specifically radar antennas.

The presentation will describe the general design principles of aperture antennas applied to the specific case of ESA design. System applications will be discussed to set the framework for requirements allocation and flowdown.

ESA performance is largely determined by the selection and limitations of specific components. The presentation will discuss the contribution of radiating elements, T/R modules, monolithic microwave integrated circuits (MMICs), microwave distribution and packaging, to performance goals, including tradeoffs to meet size, weight, power and thermal dissipation constraints. Illustrations from existing satellite ESA systems will be described to illustrate the concepts discussed in the first part of the presentation. The presentation will conclude with a detailed comparison of an L-band system satellite system.

**Organisers:**
John S Williams, The Aerospace Corporation

**Programme**

**Welcome**

09:00 - 09:10

**Antenna Architectures and Functional Partitioning**

09:10 - 10:00

The advantages and disadvantages of ESA and reflector antennas as well as ESA feeds for reflectors will be compared and contrasted. Common ESA design issues will be described, including array partitioning and subarrays, lattice tradeoffs, feed design, causes and mitigation of sidelobes, beam steering approaches and techniques for beam shaping. Numerical examples using Matlab will illustrate performance of specific designs.

10:00 - 10:40

**Practical Design Considerations**

ESA performance is largely determined by the selection and limitations of specific components. The presentation will discuss the contribution of radiating elements, T/R modules, monolithic microwave integrated circuits (MMICs), microwave distribution and packaging to performance goals including tradeoffs to meet size, weight, power and thermal dissipation constraints.

10:40 - 11:20

**Coffee Break**

11:20 - 12:00

**Operational Examples**

Recent radar satellite designs will be described to illustrate actual performance and design tradeoffs.

12:00 - 12:50

**Conceptual L-band Antennas**

Requirements, design alternatives and tradeoffs for a conceptual L-band antenna will be presented.

12:50 - 13:00

**Open discussion and concluding remarks**

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**SCF02**

**Multibeam Antennas and Beamforming Networks**

**Organisers:**
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), and RF navigation systems.

Beam-Forming Networks (BFNs) play an essential role in any antenna system, relying 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 offering different levels of complexity and performance.

The objective of the course is to present design principles and state-of-the-art in MBAs and BFNs.

**Programme**

**Welcome**

09:00 - 09:10

**Fundamentals of Multibeam Antennas**

09:10 - 09:50

Piero Angeletti, European Space Agency

1. Overview of Multibeam Antennas and System Requirements:
   - Satellite Communication Systems;
   - Wireless Communications;
   - RADARs

09:50 - 10:40

**Multibeam Antenna Architectures (Part 1)**

Giovanni Toso, European Space Agency

Reflector-Based Architectures:
- Single-Feed-per-Beam;
- Multiple-Feed-per-Beam

10:40 - 11:20

**Coffee Break**

11:20 - 11:50

**Multibeam Antenna Architectures (Part 2)**

Giovanni Toso, European Space Agency

Linear and Planar Direct Radiating Arrays (Based on Periodic or Aperiodic Lattices)
- Lens-Based Architectures (Free Space and Constrained)

**Beamforming Networks**

Piero Angeletti, European Space Agency

Analog Beamforming Networks:
- Corporate Divider/Combiners;
- Blass and Nolen Matrices
- Butler Matrices
- Digital Beamforming Networks

12:30 - 13:00

**Applications of Multibeam Antennas**

Piero Angeletti, European Space Agency

Overview of Some Operational Multibeam Antennas/ BFNs:
- MBAs for Spaceborne Narrowband and Broadband Satellite Communication Systems;
- MBAs for Wireless Communications

12:50 - 13:00

**Discussion**
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**Conference Sessions**

- **WM01**: Recconfigurable RF & Microwave Passive Components for Emerging Wireless Systems
- **WM02**: Millimetre-Wave Electronics for High Capacity Wireless Networks
- **WM03**: Additive Manufacturing for RF Passive Hardware
- **WM04**: Wireless Power Transmission for Space Applications
- **WM05**: Microwave Passive and Active Devices with Integrated Filtering Functions
- **WM06**: Advances in Millimetre-Wave 3D Printing and MCM Technologies
- **WM07**: The Basics of Travelling Wave Tube Amplifiers
- **WM08**: Current and Future Use of Spectrum by PMSE - 3rd PMSE Workshop at EuMW
- **WM09**: New Developments for Satellite Communications on the Move

**Joint Sessions**

- Joint EuMC/ EuMW
- Joint EuMC/ EuMIC
- Joint EuMC/ EuRAD

**Contribution Sessions**

- EuMW
- EuMC
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**CONFERENCE SESSIONS MATRIX - TUESDAY**

**EuMW**

**EuMC**

**EuMIC**

**EuRAD**

**Joint EuMC/ EuMW**

**Joint EuMC/ EuMIC**

**Joint EuMC/ EuRAD**

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**Welcome Reception**
<table>
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<tr>
<th>Room</th>
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<th>14:20-16:00</th>
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<th>16:40-18:20</th>
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<td>EuMC12 Focused Session: Recent Advances in the Field of Multipactor</td>
<td>EuMC18 Diode and Transistor Technology for THz Signal Generation and Systems</td>
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<td>WW02 Trends in CMOS RF ICs</td>
<td>EuMC24 Advances in Planar Filter Design</td>
<td>EuMC28 Diplexers and Reconfigurable Filters</td>
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<td>EuMC13 Advanced Technological Realisation of Microwave Filters</td>
<td>EuMC19 Additive Manufacturing and Technological Approaches for Passive Components</td>
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<td>EuRAD02 Radar Performance in Complex Environments</td>
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<td>EuMC36 High Performance Transceivers and Switches</td>
<td>EuMC43 Power Amplifier Systems</td>
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