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<tr>
<td>08:00</td>
<td>Registration</td>
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<td>S01: Power Amplifiers</td>
<td>S02: Antennas and Arrays</td>
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<td>12:40</td>
<td>Lunch Break</td>
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<td>S03: Radar Components and Systems</td>
<td>ITG/VDE Meeting</td>
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**Please note:** The exhibition will take place from 10:40-20:00.
# Program Overview Tuesday, March 13, 2018

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<th>Time</th>
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<td>S06: Characterization and Modeling</td>
<td>S07: Antenna Components and Surface Structures</td>
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<td>IMA Meeting (starts 11:30)</td>
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<td>S08: Microwave Sensors</td>
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<td>SP3: Special Session - SFB MARIE</td>
<td>S10: Microwave Tubes</td>
<td>S11: Communication Systems</td>
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<td>Transfer and Conference Dinner</td>
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**Please note:** The exhibition will take place from 09:50-16:00.
Program Overview Wednesday, March 14, 2018

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<td>S14: Passive Components</td>
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Welcome Message

German Microwave Conference, GeMiC 2018
Konzerthaus Freiburg, March 12-14, 2018

Dear GeMiC 2018 Delegate,

on behalf of:

• the German Institute for Microwave and Antenna Technologies (IMA)
• the German Association for Electrical, Electronic & Information Technologies (VDE) and its Information Technology Society (ITG)
• the Institute of Electrical and Electronics Engineers (IEEE), represented through its Germany Section MTT/AP Joint Chapter
• the European Microwave Association (EuMA)
• and the Albert Ludwig University of Freiburg (ALU)

it is our great pleasure to welcome you to the German Microwave Conference - GeMiC 2018, which is held from March 12 to 14, 2018 in Freiburg! This year we are celebrating the 11th edition of GeMiC!

In 2004, the “HF-Professoren-Treffen” – the national meeting of all professors doing research in the high frequency range in Germany – initiated the idea of a national microwave conference under the control of technical, scientific societies: “The conference should have the aim to establish a platform for young scientists to present the results of their work to the scientific community comprising universities, research institutes and industry”.

In the following year, the conference was born and the success story began with: Ulm (2005), Karlsruhe (2006), Hamburg (2008), München (2009), Berlin (2010), Darmstadt (2011), Ilmenau (2012), Aachen (2014), Nürnberg (2015), and Bochum (2016).
GeMiC has become the leading German microwave conference. Its growing national as well as international impact is reflected by the large number of high-quality contributions. GeMiC 2018 welcomes you with a scientific program consisting of eighteen oral sessions and two poster sessions.

The program will be enriched by five highly renowned keynote speakers:

**Monday – Opening Session**
James F. Buckwalter, University of California - Santa Barbara, USA  
*Energy-Efficient Circuit Techniques for Wideband, Millimeter-Wave Transmitters and Receivers*

Ludger Verweyen, Infineon Technologies, Germany  
*RF and Power Semiconductor Technologies Enabling Highly Efficient Communication Systems*

**Tuesday – Plenary Session**
Patrick Scheele, Hensoldt Sensors GmbH, Germany  
*Technology Challenges for RF Sensor Products - Boundaries, Needs and Solutions*

Elena Saenz, European Space Agency, The Netherlands  
*Challenges and Developments in (sub)mm Wave Technologies and Testing Facilities at ESA*

**Wednesday – Closing Session**
Eric W. Bryerton, Virginia Diodes, Inc., USA  
*Compact Submillimeter Wave Receivers for Nanosatellites*

The conference is complemented by workshops, short courses, a design competition and the industry exhibition. At this exhibition, you can get in touch with cutting edge instrumentation systems, simulation tools, components and subsystems in the area of microwaves. We hope that during the breaks and the social events accompanying the conference, you will find numerous opportunities for discussions and face to face exchange of latest research results.

The GeMiC Industry-Sponsored Welcome Reception on Monday, March 12, will be held in the Konzerthaus next to the posters and the exhibition.

The GeMiC 2018 Conference Dinner will take place on Tuesday, March 13, at the VOLANTE in Kirchzarten. The location gives a dedicated overview on E-Mobility, where E stands in this case for Event. Let them surprise you.
We want to express our thanks to all authors, reviewers and the Awards Team for their contributions.

We would like to thank the exhibition manager Hermann Maßler, the workshop organizer Dirk Schwantuschke and the Fraunhofer IAF organizational team Jennifer Funk, Sandra Iselin, Hildegard Brucher, Julia Roeder, Laura Hau and Anne-Julie Maurer. The kind contributions of the Liaison Officer Jósef Modelski and the VDE team Olga Oberländer and Volker Schanz are gratefully acknowledged.

We thank the German Research Foundation (DFG) for supporting GeMiC 2018.

Moreover, we highly appreciate financial and technical support by our exhibitors and sponsors AdMOS, Anritsu, ANSYS Germany, AR Deutschland, bsw TestSystems & Consulting, CST - Computer Simulation Technology, FormFactor, Globes Elektronik, Keysight Technologies, LPKF Laser & Electronics, Mician, Rohde & Schwarz, Rosenberger, SEMIC RF, TECH-INTER, Tektronix, Teledyne LeCroy, Telemeter Electronic, and WISI Automotive.
Without their kind and gracious support, GeMiC 2018 would not have been possible.

Also, we would like to express our thanks to the sponsors of the awards for the categories:
Best Paper - sponsored by the European GaAs association,
Best Student Paper - sponsored by EuMA,
Best Poster - sponsored by IMA.

Finally, we wish you all a successful and interesting conference in the green city of Freiburg.

“Ride the green waves”
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Dirk Schwantuschke Fraunhofer Institute for Applied Solid State Physics IAF

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Hermann Maßler Fraunhofer Institute for Applied Solid State Physics IAF

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Keynote Talks

Monday – Opening Session
(13:20-15:30, Room: Runder Saal)

Welcome and Conference Opening
Rüdiger Quay

James F. Buckwalter
University of California - Santa Barbara, USA

Energy-Efficient Circuit Techniques for Wideband, Millimeter-Wave Transmitters and Receivers

Millimeter-wave (MMW) integrated circuits and systems are rapidly evolving to meet requirements for high data rates. While high data rates are possible due to the relatively wide bandwidth (up to 2 GHz), gigabit-per-second MMW access and backhaul networks demand high-order QAM as well as OFDM and carrier-aggregated waveforms that force the transmitter to operate with high peak-to-average power (PAPR) waveforms. High PAPR requirements aggravate the design of MMW Si CMOS and SiGe BiCMOS circuits since a linear response and high efficiency are simultaneously required. Future MMW integrated circuit solutions must simultaneously support complex waveforms over wide signal bandwidth while minimizing the need for power hungry signal processing for equalization and predistortion. This talk proceeds from the standpoint of minimizing the overhead of equalization and predistortion to correct analog imperfections. Silicon Germanium (SiGe) continues to offer excellent MMW front-end performance. I will discuss wideband circuit innovations for frequency conversion with low gain and group delay variation to reduce the amount of wideband equalization required for high-bandwidth QAM. I will demonstrate a sliding IF transmitter and receiver architecture that requires minimum tuning range (under 3 GHz LO tuning range) while achieving high fractional bandwidth to cover 71-76 and 81-86 GHz (E-band). The sliding IF and narrow LO tuning range allows wideband image rejection while relaxing filter requirements. Measurements indicate less than ±0.75 dB variation over 10 GHz in TX mode and less than ±1 dB variation over 10 GHz bandwidth in RX mode. With 64-QAM, the EVM is below 4% at a data rate of 9 Gb/s. I will demonstrate the use of injection locking for phase shifting in millimeter-wave systems. LO phase shifting eliminates the gain variation introduced by RF and IF-path phase shifters. An E-band scheme for LO phase shifting is demonstrated as well as discussion of LO phase shifting at frequencies above 100 GHz. Finally, I will discuss recent demonstrations of SiGe-based outphasing PAs with record...
average efficiency based on a low-loss Chireix combiner implemented as a planar triaxial balun. A planar power combiner has a measured insertion loss of 0.52 dB. This extremely low loss allows the PA to reach a saturated output power $P_{SAT}$ of 23 dBm with a peak PAE of 41% at 21 dBm and a PAE of 34.7% at 6 dB backoff.

James F. Buckwalter received the B.S.E.E. degree with honors in electrical engineering from the California Institute of Technology (Caltech), M.S. degree from the University of California, Santa Barbara (UCSB), and Ph.D. degree in electrical engineering from Caltech. He was a Research Scientist with Telcordia Technologies from 1999-2000. In July 2006, he joined the faculty of the University of California – San Diego (UCSD) as an Assistant Professor and was promoted to Associate Professor in 2012.

He is currently a Professor of Electrical and Computer Engineering with UCSB. Dr. Buckwalter was the recipient of a 2004 IBM Ph.D. Fellowship, 2007 Defense Advanced Research Projects Agency (DARPA) Young Faculty Award, 2011 NSF CAREER Award, and 2015 IEEE MTT-S Young Engineer Award. He is a senior member of the IEEE and has published more than 140 conference and journal papers. His research interests include RF, microwave, millimeter-wave, and high-speed optoelectronic circuits and systems.

Ludger Verweyen
Infineon Technologies, Germany

**RF and Power Semiconductor Technologies Enabling Highly Efficient Communication Systems**

In 2015, the information and communications technology (ITC) consumed about 4% of global electricity, rising up to 20% by 2025 according to a „Climate Home“ report issued in December 2017. In the same time, the worldwide monthly mobile data traffic is expected to increase by 8x from 14ExaBytes today to >110ExaBytes in 2023. To partially compensate for this anticipated increase in energy consumption for ITCs, more efficient systems must be conceived, both in the data centers and in the communication systems. The new radio networks providing more user capacity and higher data transmission rates need to be deployed at higher operation frequencies since only there the necessary bandwidth for larger channel width will be available. 5G networks will initially be operated at frequencies below 6GHz, later
in time complemented by operation frequencies above 24GHz. Massive MIMO will be one architectural measure to reduce the power consumption of the wireless link with more bandwidth. RF components with highest efficiencies is a key requirement moving forward, also to provide cost effective solutions. Lowest power consumption is even more crucial for battery driven devices with increasing feature sets to leverage the limitations of the battery capacity. For Internet of Things (IoT) devices such as sensor hubs with connectivity MODEMs for cloud processing, a different strategy is necessary to achieve the target lifetime of 10 years without maintenance. In this presentation, we will show examples of future system concepts for power management and wireless components to derive the requirements for semiconductor technologies, and we will identify the respective sweet spots for the broad field of applications in upcoming communication systems in infrastructure and user equipment.

Ludger Verweyen started his career as a circuit designer for mmW circuits on GaAs technologies at Fraunhofer IAF in Freiburg in 1994, where he was working on the design of the first 77GHz MMICs for ACC systems. Afterwards he worked in various R&D management positions for RF communication products at TriQuint Semiconductors (now Qorvo) and Infineon Technologies, respectively.

With more than 20yrs experience in all kinds of RF applications, he currently holds a general management position at Infineon technologies for RF mobile products. Ludger received a Dipl.-Ing. and Dr.-Ing. degree in EE, both from RWTH Aachen.

Tuesday – Plenary Session  
(12:30-13:40, Room: Runder Saal)

Patrick Scheele  
Hensoldt Sensors GmbH, Germany

Technology Challenges for RF Sensor Products - Boundaries, Needs and Solutions

When developing RF/Microwave products, not only RF performance, technological challenges and trends have to be taken into account. There is a broad range of requirements coming from the use or end user of the product which have to be
considered when partitioning the solution and selecting the appropriate technologies for the realization of each and every function in a “mix and match” approach. Examples of such challenges are - New functions or shifted performance limits due to new arising possibilities in the RF Hardware - Product relevant boundary conditions like environmentalts (e.g. temperature, size, weight..) - Logistic and product lifecycle aspects (e.g. maintainability, repairability, reliability) - Safety and security aspects (Personal safety, SW and data security, cyber security…) - Costs for Developing, Manufacturing and Testing of the RF/microwave products - the essential challenge for a viable industry. The abbreviation SWaP-C summarizes several major aspects for a new product as it is typically all about the reduction or optimization of size, weight, power consumption and (recurring) cost. To simultaneously achieve these goals, several different levels in a hardware design need to be involved: - Components - especially MMICs - migrate more and more from single functionalities to multi-function Systems-on-Chip to provide complete RF functions and related circuitry (bias, digital control etc.) with shorter bills of material. - Packages and interconnects play a key role not only in electrical performance terms but also in product reliability, mechanical interfaces and thermal management - Printed circuit boards using advanced RF-on-PCB-designs integrate passive microwave components and all necessary mixed-signal functions needed for active microwave devices, including power supply and digital control interconnects - Mechanics, housing and cooling form the interface to the physical world outside the lab with distinct environmental conditions - Overall architecture of RF system like transceivers or complex AESA antennas are key to make best use of available technologies while keeping grips on cost. The presentation will discuss those topics and solutions based on a product development model case of an E-Scan capable SatCom RF-unit for the Ka-band. It will step into several of the above mentioned hardware levels and point out technological developments related to moving boundaries of current available products.

**Patrick Scheele** is with Hensoldt, Ulm, Germany, where he is currently Head of Hardware Engineering, with responsibilities for hardware development in the fields of RF/microwaves, digital electronics/computers and mechanical engineering.

He received the Dipl.-Ing. (FH) degree with honors in communications engineering from the Mannheim University of Applied Sciences, Mannheim, Germany, in the year 2000. Before starting his Ph.D. studies, he was working as a development engineer for spaceborne physical sensor electronics. In 2007 he received the doctoral degree (Dr.-Ing.) with honors from Darmstadt University of Technology, Darmstadt, Germany.

Afterwards, he was working for an OEM in the mobile phone industry as an R&D
engineer before he joined EADS, Ulm, Germany (now: Hensoldt) in 2009, where he held several different engineering positions on different sites. Dr. Scheele is recipient of the IEEE MTT-S 2013 outstanding young engineer award.

Elena Saenz
European Space Agency, The Netherlands

**Challenges and Developments in (sub)mm Wave Technologies and Testing Facilities at ESA**

The terahertz (THz) part of the electromagnetic spectrum falls between the lower frequency millimetre wave region and, at higher frequencies, the far-infrared region. The frequency range extends from 0.1 THz to 10 THz, where both these limits are rather loose. Several ESA missions mainly for remote sensing or radioastronomy are flying or planning to fly instruments working at sub-millimeter wave frequencies. In the field of Earth Observation, missions like MetOp Second generation, Meteosat Third Generation and the Geo-sounder are currently under development. In the field of Astronomy Science Herschel/Planck was successfully launched in 2009 and JUICE is being designed. The use of these high frequencies brings several advantages but at the same time challenges in the design and testing of the antennas and instruments. Three antenna measurement facilities are operational at ESTEC, the Compact Antenna Test Range (CATR), the recently upgraded Hybrid European RF and antenna Test Zone (HERTZ), and a new Sub-millimeter wave Scanner (SmS). In order to characterise the materials used for the antennas and instruments, three facilities have been developed, the Microwave and the (Sub)millimeter wave Material RF characterization facilities, and the Scatterometer. With these facilities, measurements from 400 MHz up to 750 GHz can be performed.

**Elena Saenz** (S’04–M’08) was born in Viana, Navarra, Spain, in 1981. She received the M.Sc. and Ph.D. degrees from the Public University of Navarra (UPNA), Pamplona, Spain, in 2004 and 2008, respectively, both in Telecommunication Engineering. Her doctoral research was focused on the analysis and design of meta-surfaces with emphasis on their application as superstrates for planar antennas.

Until 2008 she was with the Antenna Group, Public University of Navarra. Since then, she has been working at the Euro-
GeMiC 2018, Freiburg, Germany

European Space Research and Technology Centre (ESTEC), European Space Agency (ESA), Noordwijk, The Netherlands with main interest in frequency/polarization selective surfaces, (sub)millimetre wave technologies, antenna measurements and material characterization.

Dr. Saenz received the Loughborough Antennas and Propagation Conference (LAPC) 2006 and 2007 Best Paper Awards and the International Workshop on Antenna Technology (IWAT) 2007 Best Paper Award. In 2008, she received the IEEE Antennas and Propagation Society Graduate Research Award.

Wednesday – Closing Session
(12:10-13:30, Room: Runder Saal)

Eric W. Bryerton
Virginia Diodes, Inc., USA

Compact Submillimeter Wave Receivers for Nanosatellites

Nanosatellite platforms, such as CubeSats, offer significant advantages for radiometer platforms in terms of cost and time from mission inception to launch. The use of nanosatellites offers significant promise for many Earth science applications, where an entire constellation of small satellites can be placed in orbit at relatively low cost, with increased planetary coverage and time resolution. The increased time resolution of a nanosatellite constellation would be particularly important for monitoring the formation, evolution, and path of dangerous tropical storms. The drawbacks of these platforms include severe limitations on mass, volume, and power. For sub-millimeter (> 100 GHz) receivers, especially heterodyne receivers, these are significant concerns, since most often sub-millimeter receivers typically have low wallplug efficiencies and consist of fairly large plated systems with several connectorized modules. This problem of excess volume and DC power requirements for sub-millimeter radiometers is addressed through the application of three technology innovations. The first is the use of high-efficiency varactor diode frequency multipliers specifically designed for the most common atmospheric radiometer frequencies, decreasing the power draw of the local oscillator. The second innovation is the integration of this frequency multiplier chain with the lower-frequency power amplifiers and multipliers needed to drive that cascade into a compact package suitable for volume-limited platforms. These two innovations not only enable the use of submillimeter heterodyne receivers on nanosatellite platforms, but they also enable the option of multiple receivers.
on a single platform or the use of receiver architectures, such as polarimeters or correlation radiometers, that require multiple receiver channels. The third potentially game-changing innovation is the recent advance in short gate length transistor technology, which have pushed amplifier operating frequencies beyond 1 THz. Several demonstrations have shown low-noise amplifiers operating up to 640 GHz and above with significant gain and noise temperatures below what can be achieved with a Schottky diode receiver. The use of a LNA at the radiometer front end can minimize the LO power requirements, or even eliminate entirely the requirement for downconversion. There are however significant 1/f noise concerns that need to be addressed in order to use these very fast LNAs in a stable radiometer that can be well calibrated and therefore relevant for scientific measurements. In this paper, we give several examples of sub-millimeter receivers produced for CubeSat missions that use these innovations to meet their requirements, along with future opportunities to apply these technologies to more complex radiometers architectures.

**Eric W. Bryerton** received the B.S.E.E. in 1995 from the University of Illinois and Ph.D. in 1999 from the University of Colorado.

From 1999-2013, he was a research engineer and scientific staff member at the National Radio Astronomy Observatory (NRAO) Central Development Laboratory (CDL) in Charlottesville, VA, where his primary responsibility was the design, development, and production of the local oscillators for all the ALMA (Atacama Large Millimeter Array) receiver bands from 84-950 GHz. From 2012-2013, he also served as the Deputy Director of the CDL and North American Technical Lead for ALMA.

Since joining VDI, Dr. Bryerton has led the development of the 874 GHz receiver delivered to NASA Goddard for the IceCube mission and the 183 GHz receiver for the Mirata CubeSat mission. He is also responsible for the design and development of the integrated transceiver modules used in compact frequency extenders up to 1.5 THz.

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**Closing Remark and Awards Presentation**

Rüdiger Quay

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Sessions

Monday, March 12, 2018

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Please note: The exhibition will take place from 10:40-20:00.
09:00  Analysis and Characterization of a Load Modulated Balanced Amplifier for Base-Station Applications
Roberto Quaglia¹, Jeff Powell², Daniel Shepphard¹, Paul J Tasker¹, Steve Cripps¹
¹Cardiff University, Great Britain; ²Skyama Ltd, Great Britain

This paper discusses the analysis and the experimental results of a load modulated balanced amplifier designed for base-station applications. The hardware, employing commercially available GaN packaged devices, operates in the 1.7-2.5 GHz band, with maximum output power higher than 63 W, and with power added efficiency higher than 43% and 39% at 6 dB and 8 dB output power back-off, respectively. The analysis reveals that the proposed topology has some advantages when compared to other load modulated amplifiers, such as the Doherty, but on the other hand it shows an intrinsic non-linear behavior. This is confirmed by experimental results, where it is shown that employing a non-linear splitting function between the two branches of the amplifier improves the performances with respect to a linear splitter. Moreover, through the adoption of a proper digital splitting function and predistortion it is possible to linearize the amplifier to a level acceptable for Long Term Evolution (LTE) base-stations while maintaining a competitive average efficiency.

09:20  A 50 W Wideband Hybrid Ku-Band GaN-HEMT Power Amplifier for Satellite Communication
Daniel Maassen, Felix Rautschke and Georg Boeck
Technical University of Berlin, Germany

Within this work a hybrid Ku-band microwave integrated circuit (MIC) power amplifier (PA) is going to be described. The two-stage 250nm GaN-HEMT design operates in the frequency range of 12.5 -14.2GHz covering both Ku-band uplink frequency bands. The PA achieves more than 20% PAE over 14% FBW while holding 15 dB gain in its 1 dB compression. A high output power level of 50 W represents enough drive level for very small aperture (VSAT) as well as satellite ground station applications.

09:40  A 5 W AlGaN/GaN Power Amplifier MMIC for 25-27 GHz Downlink Applications
Stanislav Samis\textsuperscript{1}, Christian Friesicke\textsuperscript{2}, Rüdiger Quay\textsuperscript{2}, Arne F. Jacob\textsuperscript{1}  
\textsuperscript{1}Technical University of Hamburg-Harburg, Germany; \textsuperscript{2}Fraunhofer IAF, Germany

This work presents the design and analysis of a 5 W power amplifier (PA) MMIC operating between 25 and 27 GHz. The technology used is the 0.1µm AlGaN/GaN HEMT process of Fraunhofer IAF. To benchmark its performance around 26GHz two preliminary designs are synthesized and analyzed. The measured results demonstrate for the final MMIC up to 5.2 W of output power associated with 32\% of power added efficiency (PAE). A peak PAE of 35\% was observed in continuous-wave (CW) operation at a drain supply voltage of 15 V.

10:00 Q-Band GaN Power Amplifier MMICs - A Design Study  
Philip Feuerschütz\textsuperscript{1}, Christian Friesicke\textsuperscript{2}, Roger Lozar\textsuperscript{2}, Sandrine Wagner\textsuperscript{2}, Thomas Maier\textsuperscript{2}, Peter Brückner\textsuperscript{2}, Rüdiger Quay\textsuperscript{2}, Arne F. Jacob\textsuperscript{1}  
\textsuperscript{1}Technical University of Hamburg-Harburg, Germany; \textsuperscript{2}Fraunhofer IAF, Germany

Two power amplifier (PA) MMIC designs with more than 1 W of output power in the 37.5-42.5 GHz Q-band downlink band are presented. The circuits are manufactured using the Fraunhofer IAF 100 nm AlGaN/GaN process. The first one is a two-stage design in microstrip line (MSL) technology, whereas the second one is a three-stage design in grounded coplanar waveguide (GCPW) technology, which enables effective output power combining and compact layout at Q-band. A maximum output power of 2.1 W (33.2 dBm) is measured at 39 GHz with a power-added efficiency (PAE) of 14.7 \%, corresponding to a power density of 1.45 W/mm.

10:20 A 95 GHz Bandwidth 12 dBm Output Power Distributed Amplifier in InP-DHBT Technology for Optoelectronic Applications  
Tanjil Shivan\textsuperscript{1}, Nils Weimann\textsuperscript{1}, Maruf Hossain\textsuperscript{1}, Tom Johansen\textsuperscript{2}, Steffen Schulz\textsuperscript{1}, Dimitri Stoppel\textsuperscript{1}, Olivier Ostinelli\textsuperscript{3}, Colombo R. Bolognesi\textsuperscript{3}, Ralf Doerner\textsuperscript{1}, Viktor Krozer\textsuperscript{1}, Wolfgang Heinrich\textsuperscript{1}  
\textsuperscript{1}Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin, Germany; \textsuperscript{2}Technical University of Denmark, Denmark; \textsuperscript{3}ETH Zurich, Switzerland

This paper presents a DC-95 GHz distributed amplifier (DA) based on an InP/GaAsSb/InP 800 nm DHBT technology. The circuit employs five cascode unit cells with 0.8 µm × 6 µm HBTs. To obtain flat small-signal gain and group delay characteristics, inductive peaking is used at the collector of the common-base transistor. The amplifier exhibits 12 dB gain from 1-100 GHz, with S11 and S22 below -10 dB throughout the frequency range. DC consumption is only 126 mW and group delay remains below 20 ps up to 65 GHz. The simulated saturated output power reaches 12 dBm with a variation of ±0.75 dB across the entire band of operation. This performance is very useful in high-speed, ultra-low power optical systems.
**S02: Antennas and Arrays**

Chairs: Arne F. Jacob (Technical University of Hamburg-Harburg, Germany), Michael Schneider (Airbus, Germany)

Room: Runder Saal 09:00-10:40

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**09:00**  
**X-Band Downlink Antenna Characterised by Isoflux Gain Mask**  
Michael Kilian, Christian Hartwanger, Andreas Schinagl-Weiβ and Michael Schneider  
*Airbus Defence and Space GmbH, Germany*

This paper presents development and measurement results of a X-band isoflux downlink antenna. Isoflux antennas have to fulfil strict requirements concerning pattern mask, cross polarisation and backlobes. To satisfy these requirements and simultaneously providing circularly polarised waves, a compact polariser was matched and combined with a specific horn geometry. The antenna was manufactured, tested and delivered as flight model to enlarge time slots for transmitting big data [1] between Earth observation satellites and ground stations. This paper discusses pros and cons of isoflux antennas and summarises the manufactured hardware as well as corresponding measurement results.

**09:20**  
**Dual-Polarized Dual-Frequency Antenna Module for a Maritime Phased Array Radar**  
Stefan Radzijewski, Nils Hansen, Jan-Philip Mohncke and Arne F. Jacob  
*Technical University of Hamburg-Harburg, Germany*

A dual-polarized dual-frequency antenna module for a future commercial navigation radar is presented. The module is comprised of three X-band antenna columns as well as one S-Band antenna column. All antennas feature dual-polarization capability and are the basic antenna cell for a full phased array realization of the radar system.

**09:40**  
**A Pattern Reconfigurable Antenna System for Automotive MIMO Applications**  
Jerzy Kowalewski, Ibrahim Mehinović, Sevda Abadpour, Jonathan Mayer and Thomas Zwick  
*Karlsruhe Institute of Technology (KIT), Germany*

This paper presents the design and evaluation of a multiple-input multiple-output (MIMO) antenna system consisting of pattern reconfigurable antennas. The reconfigurable antennas used are based on radiating elements that are fed in parallel and two possible phase differences between them can be switched with p-i-n diodes. Two parasitic elements in vicinity of one of the antennas enable the generation of
further two directive patterns. The radiation patterns realized by this MIMO system are optimized for automotive urban scenarios based on the results of previous research. As a proof of concept the patterns realized by these antennas are evaluated in a channel simulation and different arrangements on a car’s roof are investigated. The simulation results considering various scenarios show the improvement in channel capacity by as much as 4 bit/s/Hz and 3 bit/s/Hz compared to system using monopoles for rural and urban cases respectively.

10:00  A Non-Reciprocal Receive Array with Large Beamwidth and Gain
Jonas Kornprobst, Thomas J. Mittermaier and Thomas F. Eibert
Technical University of Munich, Germany

A non-reciprocal self-mixing receive antenna array is presented. First, the principle of the self-mixing concept is explained and it is found that self-mixing receivers achieve a large gain over a wide angular range, which is in contrast to reciprocity. In the second part, the design of a 4×2 antenna array operating from 34 GHz to 39 GHz including the receive amplifier and mixer is introduced. Measurements in an anechoic chamber verify the simulation results, showing promising results for future applications of self-mixing arrays with a wide angular receiving range.

10:20  Design, Simulation and Fabrication of Low Cost UHF RFID Reader Antenna for Hospital Applications
Vinicius Uchoa Oliveira¹, Glauco Fontgalland¹, Raquel Rodrigues¹,², Clesio Melo²
¹Universidade Federal de Campina Grande - UFCG, Brazil; ²Universidade Federal do Piauí - UFPI, Brazil

This paper presents a development of low-cost single band antenna for fixed ultra-high frequency (UHF) radio-frequency identification (RFID) reader for surveillance and tracking high valuable items in hospitals. The proposed low-cost antenna is made of recycling waste of aluminum sheets and consists of two parallels plates (a ground plane and a radiator) with an L-shaped metal strip between them and four short plates (stubs) for tuning. A bandwidth of 39.63 MHz and 3.1 dBi for directivity at 915 MHz was obtained in CST Studio. Experimental results in an anechoic chamber of a fabricated prototype showed that the antenna has desirable performance, with bandwidth of 51.63 MHz at the end, an application was proposed, and the antenna was successful in identifying assorted items with UHF tags attached at various distances.

PO1: Interactive Poster Session 1
Chair: Christian Friesicke (Fraunhofer IAF, Germany)
Room: Hall 11:00-12:40
Novel Microstrip Bandpass Filter with Wide Stopband
Mohamad Farhat
Australian College of Kuwait, Kuwait

This paper describes a compact microstrip bandpass filter exhibiting a very wide stopband and high selectivity. The filter comprises of asymmetric resonator structures which are interconnected by an inter-digital capacitor to enable the realization of a wide bandwidth with high rejection level. High selectivity is obtained by optimizing the parameters of the interdigital capacitor. Full-wave electromagnetic simulator ADS (Mom) is used to analyze and optimize the prototype bandpass filter. Experimental results were used to verify the theoretical predictions of the proposed filter.

Methodology of Isolation Improvement for an Absorptive Switch
Muh-Dey Wei and Renato Negra
RWTH Aachen University, Germany

This paper presents a general methodology to improve isolation of an absorptive switch. The concept is to counteract leakage signal at the output of a switch in the OFF state by a replica acquired from input signal. Two couplers, an attenuator and a phase shifter are used to demonstrate this concept. Amplitude and phase deviations from an ideal replica, which the same amplitude and is in antiphase with the leakage signal, are discussed in terms of isolation. A commercial switch, which has an isolation of 21.4dB and an insertion loss of 1.8dB at 2.43GHz, is used to demonstrate the methodology. Measured peak isolation of 69.4dB and insertion loss of 3.8dB are obtained. The switch achieves significant isolation improvement of 48dB, with 2dB insertion loss degradation. Furthermore, isolation improvement is effective from 2.09 to 2.9GHz (32.5%). Measured S11 within this range is below -17dB in the OFF state.

A D-Band SPDT Switch Utilizing Reverse-Saturated SiGe HBTs for Dicke-Radiometers
Barbaros Cetindogan¹, Berktug Ustundag²; Esref Turkmen³, Matthias Wietstruck¹, Mehmet Kaynak¹, Yasar Gurbuz³
¹IHP - Leibniz-Institut für innovative Mikroelektronik, Germany; ²University of California - San Diego, USA; ³Sabanci University, Turkey

This paper presents a low insertion loss and high isolation D-band (110-170 GHz) single-pole double-throw (SPDT) switch utilizing reverse-saturated SiGe HBTs for Dicke-radiometers. The SPDT switch design is based on the quarter-wave shunt switch topology and implemented with further optimizations to improve the overall insertion loss and decrease the total chip size in a commercial 0.13-um SiGe BiCMOS technology. Measurement results of the implemented SPDT switch show a minimum insertion loss of 2.6 dB at 125 GHz and a maximum isolation of 30 dB at 151 GHz.
while the measured input and output return loss of is greater than 10 dB across 110-170 GHz. Total power consumption of the SPDT switch is 5.3 mW while draining 5.6 mA from 0.95 V DC supply. Overall chip size is only 0.5x0.32=0.16 mm2, excluding the RF and DC pads.

**Digitally Controlled Vector Modulator SiGe MMIC for Millimeter-Wave Phased Array Applications**
Mikko Kantanen, Jan Holmberg, Mikko Varonen and Arto Rantala
*VTT Technical Research Centre of Finland, Finland*

This paper presents a digitally controlled vector modulator integrated circuit aimed for millimeter wave phased array systems. The vector modulator operates over 60-100 GHz range covering 360 degree phase and over 10 dB gain control ranges. The maximum gain of 35.6 dB is achieved at 96.8 GHz. The chip is processed in 0.13 um silicon germanium technology. Size of the chip including the pads is 2.1 x 0.7 mm² from which the vector modulator core occupies 0.45 x 0.30 mm².

**Low-Power Multiband Hybrid VCO for 77/81 GHz FMCW Long Range Radar Applications**
Erkan Bayram, Oner Hanay and Renato Negra
*RWTH Aachen University, Germany*

This paper presents the first multiband hybrid VCO operating between 75 GHz and 81 GHz allocated for the long range FMCW radar applications. The proposed design consists of an accumulation-mode varactor and a capacitor bank which are used for the fine and coarse frequency tuning, respectively. With the multimode tuning technique, the proposed VCO solves the tuning range problem in the coarse tuning path while minimising frequency linearity variation in the fine tuning path. The proposed hybrid VCO is implemented in a TSMC 65 nm CMOS technology. The tuning range of the VCO is from 75 GHz to 80.8 GHz. The simulated average phase noise is −94 dBc/Hz at 1 MHz offset between 75 GHz and 80.8 GHz. It dissipates 3.54 mW from 1.2-V supply.

**A 8-Channel Baseband Data Acquisition Platform for Digital Beamforming Radars**
Aly Marnach, Andreas R. Diewald and Simon Müller
*Trier University of Applied Sciences, Germany*

The goal of this work is a platform, which can be used in multiple areas. The laboratory of applied radar technology and optical systems of our university occupies with signal processing of radar and camera systems, as well as the design of new radar systems for various fields of applications. At this point a platform for students should
be created where they can improve their knowledge about signal processing. For this an eight channel radar system is used as signal source but the platform is not linked to this radar system so that it can be reused for other projects as well. It digitizes the eight signal channels from the radar system simultaneously and provides it in a MATLAB environment, where students can analyze the signals in many ways. The platform will be used in lectures as Microwave technology, Computer architecture and Signal Processing for laboratories.

**Thorough Analysis of Multipath Propagation Effects for Radar Applications in the Vehicle Interior**

Andreas R. Diewald¹, Andreas Fox², Dimitri Tatarinov²

¹Trier University Of Applied Sciences, Germany; ²IEE S.A., Luxembourg

The authors present a method to determine the amount of reflected power of a radar target in a multi-scattering environment based on a numerical approach. In the actual research a radar sensors is mounted in the vehicle interior in order to detect children which are left behind on the rear bench by accident. Due to the multi-scattering environment of the vehicle interior the different receiving waves at the CW radar are interfering constructively and destructively. In this paper the amount power purely reflected by the child and reflected by the environment is separated and analysed.

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**SP1: Special Session - FOR MUSIK**

**Multiphysical Synthesis and Integration of Complex High-Frequency Circuits**

Chair: Uwe Stehr (Technical University of Ilmenau, Germany)

Room: K2-4 11:00-12:40

**11:00** Multiphysical Design Methodology for the Heterogeneous Integration of an RF Receiver

Victor Silva Cortes¹, Uwe Stehr², Johannes Stegner²; Jacek Nowak², Matthias Hein², Ralf Sommer²; Georg Fischer¹, Amelie Hagelauer¹

¹University of Erlangen-Nuremberg, Germany; ²Technical University of Ilmenau, Germany

A multiphysical design methodology dealing with the heterogeneous integration of microelectronic and micro-electro mechanical systems (MEMS) suitable for modern RF transceiver is presented. The proposed approach focuses the design and verification efforts on the transceiver performance requirements by providing the specification and evaluation scopes at the different abstraction levels. The methodology is
demonstrated for an LTE user equipment receiver consisting of a low noise amplifier (LNA) and a MEMS-based oscillator for the down conversion stage. The evaluation of the demodulation performance shows the impact of the LNA and the oscillator on the overall system.

11:20  Design and Implementation of a MEMS-Based RF Oscillator on a Unique Silicon-Ceramic Composite Substrate
Johannes Stegner, Michael Fischer, Sebastian Gropp, Uwe Stehr, Jens Müller, Martin Hoffmann and Matthias Hein
Technical University of Ilmenau, Germany

In times, where the number of communication standards in mobile devices is growing, parameters like functional density, integrability, and power consumption become more and more important. Especially high frequencies and low channel bandwidths are the challenges that increase the need for new technology approaches and integration techniques. Microelectromechanical systems (MEMS)-based designs can overcome traditional design trade-offs by high resonant frequencies and simultaneously high quality factors and small geometrical dimensions. This paper reports the design, implementation, and packaging of a compact MEMS-oscillator module on a silicon-ceramic composite substrate. First measurements show a good phase-noise performance, i.e. −80 dBc/Hz at an offset of 1 kHz. This underlines the capabilities of MEMS oscillators on this unique substrate: a small module size and low phase noise by reducing the substrate influence present in conventional oscillator designs.

11:40  Multiphysical Design of Compact RF Modules on a Silicon-Ceramics Substrate
Uwe Stehr, Johannes Stegner, Michael Fischer, Sebastian Gropp, Jens Müller, Martin Hoffmann and Matthias Hein
Technical University of Ilmenau, Germany

In the upcoming „Beyond Moore“ era of technology development, raw transistor scaling becomes less important to differentiate one design from another. Instead, the incorporation of multiphysics elements, like microelectromechanical system (MEMS) devices, is a key path to further increase the overall performance and functional density of a RF system. Within this work, a new heterogeneous integration concept, based on a silicon-ceramics composite substrate approach, is detailed that can be used for a compact integration of MEMS devices together with microelectronic components. In the paper, the substrate construction is described briefly, and the integration of core elements like MEMS resonators and switches is depicted and the inherent advantages of the concept are revealed. A LTE RF frontend as a technology demonstrator is presented which illustrates the developed concepts.
12:00  Thermal Modeling and Measurement of a Power Amplifier Module for a Silicon-Ceramic Substrate
Astrid Frank1; Victor Silva Cortes2; Georg Fischer2; Amelie Hagelauer2; Steffen Michael1
1IMMS Institut für Mikroelektronik- und Mechatronik-Systeme Gemeinnützige GmbH, Germany; 2University of Erlangen-Nuremberg, Germany

The present paper describes the modeling and measurement of thermal dissipation of a power amplifier (PA) on a printed circuit board (PCB). Its influence on its surrounding is to be examined in view of assembly on a silicon-ceramic (SiCer) composite substrate. The thermal impact on the performance of the PA and its power dissipation are determined by harmonic balance simulation and measurements. Based on these simulations, an integrated design of a demonstrator system on SiCer is pursued.

12:20  Application of X-Parameters in Studying Nonlinearities in BAW and SAW Filters
Vikrant Chauhan, Yunshi Liang, Yucheng Liao, Victor Silva Cortes, Robert Weigel and Amelie Hagelauer
University of Erlangen-Nuremberg, Germany

Nonlinearity can give rise to intermodulation distortions and harmonics in Bulk Acoustic Wave (BAW)/Surface Acoustic Wave (SAW) devices operating at high input power levels. To understand such undesired effects, behavioral model based on the Poly-Harmonic Distortion (PHD) principle can be used as a possible modeling approach to accurately predict the nonlinear behavior of BAW/SAW filters and duplexers. In order to investigate the origin of nonlinear response of BAW/SAW devices, it is necessary to study some properties of the materials used within the devices. In this work, the nonlinear Mason models of BAW/SAW filters are created and compared with the X-parameters measurement. In the next step, role of materials in the generation of nonlinearities in BAW/SAW devices are discussed. The X-parameter measurements based modeling of SAW/BAW components up to third order harmonics and intermodulation products have been carried out with a nonlinear vector network analyzer (NVNA).

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**S03: Radar Components and Systems**
Chairs: Thomas F. Eibert (Technical University of Munich, Germany),
Viktor Krozer (University of Frankfurt am Main, Germany)
Room: Runder Saal 11:00-12:40
11:00  Cross-Polarized Planar Reflector for Polarimetric Radar Calibration at 77 GHz
Tristan Visentin\textsuperscript{1}, Rossen Michev\textsuperscript{1}, Juergen Hasch\textsuperscript{1}, Thomas Zwick\textsuperscript{2}
\textsuperscript{1}Robert Bosch GmbH, Germany; \textsuperscript{2}Karlsruhe Institute of Technology (KIT), Germany

In this paper, a printed circuit board (PCB)-based planar cross-polarized reflector is designed and fabricated for polarimetric radar calibrations at 77 GHz. The reflecting structure consists of a double-cladded substrate material with an etched strip grid on the front and a ground plane on the back. Initial design and parameter optimization are based on unit cell simulations. Next, a full-wave simulation of a small version of the structure is performed in order to verify the unit cell results and to consider edge effects at the boundaries of the finite surface. Finally, a 24 cm x 24 cm version of the optimized structure is fabricated and measured in an anechoic chamber with a fully polarimetric radar system operating at 77 GHz. The results are compared to that of a 45°-rotated dihedral. A measured cross- to co-polar isolation of 20 dB in boresight direction in the 76 - 78 GHz band proves the feasibility of the proposed structure.

11:20  A Liquid Crystal Based Tunable Polarization Selector in a Microwave Imaging Radiometer
Matthias Nickel\textsuperscript{1}, Christian Schuster\textsuperscript{1}, Holger Maune\textsuperscript{1}, Rolf Jakoby\textsuperscript{1}, Stephan Dill\textsuperscript{2}, Markus Peichl\textsuperscript{2}
\textsuperscript{1}Technical University of Darmstadt, Germany; \textsuperscript{2}German Aerospace Center (DLR), Germany

Polarimetric measurements, i.e. the analysis of electromagnetic waves with respect to their polarization, is of interest in remote sensing applications to analyze materials or to increase the visual quality of imaging technologies. One well known application in the optical domain is the polarizing filter used by photographers to reduce unwanted reflections or to increase sky contrast. In this paper, the application in the microwave domain is studied on a microwave imaging radiometer combined with an electrically tunable polarization selector based on liquid crystal. With this setup, radiometric images of a car have been captured for different polarization angles. By this, the polarimetric properties of some car features can be observed. Further, a reaction time measurement has been conducted for the utilized polarization selector, showing stable polarization states after 100 s and 250 s depending on the polarization state.

11:40  A Four-Channel Radar System for Rear Seat Occupancy Detection in the 24 GHz ISM Band
Andreas R. Diewald\textsuperscript{1}, Markus Hoffmann\textsuperscript{2}, Dimitri Tatarinov\textsuperscript{3}
\textsuperscript{1}Trier University of Applied Sciences, Germany; \textsuperscript{2}IEE S.A., Germany; \textsuperscript{3}IEE S.A., Luxembourg
A measurement system to detect people sitting on the rear bench of a car has been developed for which a four-channel imaging radar system at 24GHz ISM with a bandwidth of 250MHz is used. On the radar system an antenna array with a dedicated radiation pattern is applied. Based on a FMCW modulation approach it is possible to measure the range and the motion of the passenger in the back of the car. A DBF approach is applied on the four receiver channels in order to measure the angle of arrival. Thus it would be possible to determine the seat location of the passenger. The data acquisition is done with an ADC from National Instruments. The signal processing and evaluation of the results is performed with Matlab.

12:00  Motion Sensing of a Wind Turbine Prototype Using a Bistatic FMCW Doppler Radar Sensor

Jochen Moll¹, Rahmi Salman²,³, Dimitry Pozdniakov², Andreas Nuber⁴, Herbert Friedmann⁴, Philip Arnold¹, Moritz Mälzer¹, Viktor Krozer¹
¹University of Frankfurt am Main, Germany; ²HF Systems Engineering GmbH & Co. KG, Germany; ³Hübner Holding GmbH, Germany; ⁴Wölfel Engineering GmbH + Co. KG, Germany

Mechanical vibrations are widely used in structural health monitoring systems to evaluate the structure’s stability and to detect changes in the dynamic behaviour that are potentially related to a structural damage. Radar technology is used in recent years to measure structural vibrations at stand-off distance. This paper reports on an experimental case study in which a frequency-modulated continuous wave (FMCW) radar sensor operating in the frequency band from 33.4 GHz to 36.0 GHz was used to detect the mechanical motion of a wind turbine structure in a laboratory environment. Besides the radar system we present pulse based transient signal processing that show the feasibility of our approach.

12:20  Radar-Based Altitude over Ground Estimation of UAVs

Markus Schartel¹, Ralf Burr², Pirmin Schoeder¹, Gilberto Rossi¹, Philipp Hügler¹, Winfried Mayer³, Christian Waldschmidt¹
¹University of Ulm, Germany; ²Ulm University of Applied Sciences, Germany; ³Endress + Hauser GmbH & Co. KG, Germany

A 26GHz low-cost, low power, and low complexity pulse correlation radar (PCR) for online altitude over ground estimation of an unmanned aerial vehicle (UAV) is presented. In the experimental part of this paper, measurement results of the customized lightweight radar are shown. Therefore, this radar, a commercial available lidar sensor, and a real time kinematic global navigation satellite system (RTK GNSS) are mounted on a UAV. It is shown that in sparse vegetation, the radar in combination with a particle filter outperforms the lidar sensor. Besides, it is explained, why strong radar reflections can lead to a time offset of the particle filtered altitude. As an application, a radar-based terrain map is presented.
SP2: Special Session - FOR BATS
Low-Power Telemetry and Locating Systems
Chairs: Thorsten Nowak (University of Erlangen-Nuremberg, Germany),
Robert Weigel (University of Erlangen-Nuremberg, Germany)
Room: K2-4 16:00-17:40

16:00  Power Management Unit for a Self-Sustaining Low Power Wide Area (LPWA) Base Station
Michael Schadhauser, Joerg Robert and Albert Heuberger
University of Erlangen-Nuremberg, Germany

In the design process of base stations, reliability and maintenance expenses are probably the dominant optimization targets. Yet, it was observed, that especially energy efficiency and environmental sustainability have been emerging concerns in the layout of base station systems in recent years. This process established the term of a Green Base Station, a base station that is operated by a hybrid energy feed via the mains grid and regenerative energy resources like wind and sun. In a previous paper related to the so-called BATS project, we introduced the design of a Low Power Wide Area (LPWA) sensor network base station, receiving vitality data of sensor nodes attached to bats. In this paper, we present the extension of the aforementioned base station in line with the Green Base Station concept, aiming at a self-sustaining operation. Therefor, the hardware design of a specialized Power Management Unit (PMU) is presented, serving the needs of telemetry base stations in the BATS project. Moreover, we address the software framework that runs the PMU and illustrate the design considerations of both, its hardware and software modules. Initial results of a field trial in Berlin, Germany are presented, showing possibilities for even further improvements.

16:20  LPWAN Occupancy Model Parameter Identification for License Exempt sub-GHz Frequency Bands
Sebastian Rauh, Joerg Robert, Michael Schadhauser and Albert Heuberger
University of Erlangen-Nuremberg, Germany

For many applications Low Power Wide Area Networks (LPWANs) are an appealing method to provide cost efficient connectivity to many small and battery-driven devices spread over large areas. Also in the research project „BATS“ we are using a LPWAN to achieve connectivity for very tiny sensor nodes mounted on bats. The long-range transmission in LPWANs is mainly achieved by very low payload bit-rates, which allow error-free decoding at very low reception levels. However, LPWANs are typically operated in the license exempt sub-GHz frequency bands. This means they
have to share the spectrum with other devices also operated in these bands, which can impair the LPWAN signals. First, the other devices may not be able to detect the LPWAN signal due to its low signal level. Hence, schemes such as Listen Before Talk (LBT) do not work properly. Second, the low payload bit-rate leads to a long transmit duration of up to several seconds. This significantly increases the probability that the LPWAN signal gets hit by the signal of an interfering device. In order to analyze the impact of interference on LPWAN signals the IEEE 802.15 Interest Group LPWA has defined an interference model that can be used for detailed Physical Layer (PHY) simulations. In order to define suitable parameter sets for this interference model we propose a processing framework based on image processing. This framework allows a broadband analysis of license exempt frequency bands. It is able to identify signals parameters such as access length, arrival rate, center frequency, and bandwidth. These obtained values can then be used as input parameters of the IEEE 802.15 interference model or other channel occupancy models. We present exemplary measurement results that we obtained during a field trial as part of the BATS project in Berlin, Germany.

16:40 Simultaneous Position and Channel Parameter Estimation Applying Adaptive Kalman Filters
Thorsten Nowak, Markus Hartmann and Jörn Thielecke
University of Erlangen-Nuremberg, Germany

Recently, location-based services have become very popular. Ubiquitous positioning is elementary for the the Internet of Things. Hence, obtaining precise location information is a core feature of recent wireless sensor networks (WSNs). Besides of location-awareness, energy-efficiency is another essential property of a modern sensor network. RSSI-based direction finding is a prospective approach for WSNs providing low-power positioning. However, radio-based localization techniques, including RSSI-based direction finding, are prone to fading effects of the wireless propagation channel. Therefore, a-priori knowledge of channel parameters is inevitable for precise positioning. Fading parameters rapidly change when traversing different environments. Thus, a-priori channel knowledge can not be expected. In this paper, we apply adaptive Kalman Filters to the problem of simultaneous estimation of position and channel parameters. Applicability is proven by simulations and in a field trial tracking bats in a forest.

17:00 Improved Localization Method in a WSN by Using Frequency Diversity and an Channel Model
Markus Hartmann, Thorsten Nowak, Joerg Robert, Jörn Thielecke and Albert Heuberger
University of Erlangen-Nuremberg, Germany
In wildlife tracking the challenges for localization systems are the resource limitations e.g. weight, size and energy consumption. A very resource efficient localization system based on received signal strength (RSS) is presented. The effects of frequency diversity are used to improve the localization accuracy. Furthermore, two different localization methods based on the RSS are compared. A method based on RSS difference measurements with directional antennas for a direction of arrival (DoA) estimation and an enhanced method based on an path-loss model for combined DoA and range estimation. For both methods the localization results are discussed and the used models are presented. Finally, the measurement results of a field trail show the real localization accuracy improvements of the frequency diversity and the enhanced localization approaches.

Niklas Duda¹, Robert Weigel¹, Alexander Koelpin²
¹University of Erlangen-Nuremberg, Germany; ²Technical University of Brandenburg Cottbus, Germany

In this paper an enhanced version of the mobile node developed in the BATS project for small sized animals like bats is proposed. The new design uses highly integrated components and a more compact design. In the paper the new design is described with focus on the conducted changes. The new design has been proven in field test in Germany from which first results are shown. Special focus is put on the power supply and mobile node runtime. For pure encounter detection a runtime of more than 420 hours. Without any communication with other nodes the power is as little as 50 uA while still being in active mode.

S04: Filters
Chairs: Michael Höft (University of Kiel, Germany), Holger Maune (Technical University of Darmstadt, Germany)
Room: K9 16:00-17:20

16:00  Direct-Coupled Resonator Filters based on Foreshortened Coaxial Transmission Line Resonators
Joerg Schoebel¹, Carsten Monka¹, Jan Fahlbusch²
¹Technical University of Braunschweig, Germany; ²SF Microwave GmbH, Germany

In this paper we present certain canonical filter structures that appear to have previously been overlooked. We systematically discuss direct-coupled series- and shunt-
resonator-based coaxial filter topologies and elucidate the progression from lumped elements to foreshortened transmission-line resonators with their respective advantages and disadvantages. This finally leads to an unconventional direct-coupled foreshortened series-resonator design. This design may also be interpreted as the series-coupled foreshortened series-resonator “dual” equivalent to the comb-line filter (which is a parallel-coupled foreshortened shunt-resonator filter). Consequently, both topologies exhibit similar advantages, such as compact size, low loss and higher passband suppression. In addition, aspects of practical design of coaxial filters are covered in this paper. We provide the impedance and admittance slopes for Lambda/8 resonators, which turn out surprisingly simple. We propose a novel variant of impedance inverter, which allows for a large range of coupling coefficients in series-resonator filters. This enables narrow as well as medium-to-large bandwidth filters and additionally offers freedom to choose parameters for simple and low-cost implementation. Based on this concept, an optimized high-power bandpass filter for the 900 MHz mobile telephone downlink bands is presented, which can be fabricated at low cost.

16:20 A Compact Half-Mode Substrate Integrated Waveguide Filter Based on Circular Resonator
Ahmad Bader Alothman Alterkawi¹, Maurizio Bozzi², Mustafa Bakr¹, Reinhard Teschl¹, Wolfgang Boesch¹
¹Technical University of Graz, Austria, ²University of Pavia, Italy

In this paper, preliminary results for a compact Ultra-WideBand (UWB) filter are presented. The filter is based on a Half Mode Substrate Integrated Waveguide (HM-SIW) with a circular resonator. The proposed filter operates at the fundamental mode and is designed to be resonating at 4.1 GHz with a bandwidth (BW) of 1900MHz. The simulation results show that the filter has an insertion loss (IL) of 1.8dB.

16:40 Fast and Accurate Tuning of a Cross-Coupled Split-Ring Resonator Filter
Christian Schuster¹, Daniel Miek², Ersin Polat¹, Holger Maune¹, Rolf Jakoby¹, Michael Höft²
¹Technical University of Darmstadt, Germany; ²University of Kiel, Germany

This work addresses the design and tuning of a Cross-Coupled split-ring microstrip resonator filter. The filter is designed for a center frequency of 1.65 GHz while having a bandwidth of 65 MHz. The selectivity of the filter is increased by introducing a cross coupling between the first and fourth resonator generating two real transmission zeros. Tunability is achieved by using thin film barium strontium titanate (BST) varactors with which the center frequency of each resonator is tunable. Furthermore they enable tuning of the coupling between resonator one and two and resonator
three and four. A fast and accurate tuning of the proposed filter is achieved by using the Cauchy-Method algorithm and an implementation of a powerful optimization technique. As a result a more reliable algorithm is obtained for a better fitting between coupling matrix and measured s-parameters. The robustness of the algorithm is demonstrated by extracting the coupling matrix of a strong detuned filter tuning state.

17:00 Frequency Agile Filter for Image Frequency Rejection in an Adjustable Receiver Frontend
Thomas Lautenbacher¹, Georg Fischer¹, Matthias Fehr², Robert Weigel¹, Alexander Koelpin³
¹University of Erlangen-Nuremberg, Germany; ²Association of Professional Wireless Production Technologies e. V., Germany; ³Technical University of Brandenburg Cottbus, Germany

In this paper the investigation on a frequency agile filter circuit with bandpass-bandstop characteristic is presented. The filter is intended for an application in a frequency agile RF frontend. First of all, a theoretical examination of the tuning behavior for a second order tunable bandstop filter is conducted with analytic calculations and simulations. Main focus is on the constant frequency difference between passband and stopband in the whole tuning range. Subsequently, the proof of concept is established by implementing two demonstrator filter circuits using SMD components. Therefore, the lack of access to tunable inductances is solved by either switching inductances or changing the circuit topology according to the requirements.

S05: mm-Wave Antennas and Systems
Chairs: Dirk Heberling (RWTH Aachen University, Germany), Jan Hesselbarth (University of Stuttgart, Germany)
Room: Runder Saal 16:00-17:40

16:00 On-Chip Mounted Millimeter-Wave Dielectric Resonator Antenna
Zunnurain Ahmad and Jan Hesselbarth
University of Stuttgart, Germany

An on-chip dielectric resonator antenna is presented. A cylindrical dielectric resonator is used as a radiator. It is tilted sideways and is placed partly inside a shallow crate cut out in the chip area. An on-chip microstrip quarter-wavelength resonator excites the dielectric resonator. Besides the advantageously easy and precise on-chip alignment, the antenna offers very wide beamwidth together with reasonable frequency
bandwidth and high radiation efficiency. Using an alumina cylinder of 1 mm diameter and 1 mm length, an antenna operating at 80 GHz is presented, showing bandwidth (input reflection below -10dB) of 3% and simulated peak efficiency of 65%.

16:20 Millimeterwave Dielectric Rod Antenna with a Circuit Board Surface Mount Feed
Zunnurain Ahmad and Jan Hesselbarth
*University of Stuttgart, Germany*

A design for a dielectric rod antenna integrated with a three-dimensional metallic structure is presented for applications in the 60 GHz unlicensed band. The dielectric rod antenna is mounted on a structure made out of metallized plastic, which can be soldered on a thin microstrip circuit board. The dielectric rod antenna operates in the license-free 60 GHz band with a measured 10 dB impedance bandwidth of approximately 11%. The antenna shows a gain of more than 11 dBi and the efficiency value remains above 90 % for the overall band of 57-64 GHz.

16:40 A 60 GHz Circularly Polarized Antenna Array for Line-of-Sight Train-to-Train Communication
Amar Al-Bassam, Alshrafi Wasim and Dirk Heberling
*RWTH Aachen University, Germany*

In this paper, an antenna module of ultra-low latency system for line-of-sight train-to-train communication is presented. The antenna module consists of a high-directivity 60 GHz circularly-polarized antenna array, which consists of slot-fed truncated-corner patch antennas. Furthermore, it consists of a microstrip-to-stripline via transition and Balun to provide balanced line to be integrated to mm-wave transceiver chip on the RF-frontend. Additionally, a radome has also been designed to protect the antenna against the open environment, since it will be integrated at the mechanical coupler of a train. Finally, measurement results of the antenna module with the radome will be provided, which shows relatively low sidelobe level and 5.1 GHz axial ratio (AR) bandwidth.

17:00 Design of Leaky-Wave Antennas Based on PCB Dielectric Constant for Wide Angle Beam Steering
Kyriakos Neophytou¹, Matthias Steeg², Stavros Iezekiel¹, Andreas Stöhr²
¹*University of Cyprus, Cyprus; ²University of Duisburg-Essen, Germany*

In this paper a PCB based leaky-wave antenna (LWA) design for wide angle beam steering is presented. This design employs longitudinal slots inserted into a substrate-integrated waveguide for operation in the mm-wave V-band. The design is optimized for a reduced open-stopband and linear through broadside beam steering.
The base design is outlined and adapted for three high frequency laminates with different dielectric constants. It is further described how the dielectric constant directly affects the beam steering properties of the LWA and how to scale the achieved beam angle of the given design by only changing the PCB material. The three LWA designs achieve beam steering from about 45° at $\varepsilon_r = 2.2$, over 60° at $\varepsilon_r = 6.15$ to 75° at $\varepsilon_r = 10.7$. The simulated radiation patterns show a flat gain of up to 18.0 dBi, 17.85 dBi and 15.27 dBi, respectively. Furthermore, the effect of the changed PCB permittivity on the radiation efficiency as well as multiuser support with a beam per user is investigated.

17:20  **Low-Latency GbE 60 GHz TDD Transceiver Using SiGe-RFICs and PCB-Leaky-Wave Antennas**  
Matthias Steeg¹, Mason Lange¹, Yigal Leiba², Andreas Stöhr¹  
¹University of Duisburg-Essen, Germany; ²Siklu Communications Ltd., Israel

In this work a low-cost and low-latency 60 GHz beam steering transceiver solution for 5G hot-spots is presented. The beam steering capabilities are provided by a PCB based leaky-wave antenna via frequency scanning, which requires only one RF port and does not add latency. The LWA provides up to 20 dBi directivity over 20 GHz of operational bandwidth. In this bandwidth over 40 deg beam steering can be achieved. The employed SiGe transceiver chip is highly integrated including RF and baseband amplifier chains, mixers, filters and a voltage controlled oscillator, with control loop. Thereby, it can directly support the frequency based beam steering approach. The SiGe is based on foundry BiCMOS technology making its fabrication scalable and low-cost. With the transceiver and the LWA a Gigabit-Ethernet (GbE) wireless 60 GHz bridge is set up, which provide GbE duplex communication with a commercial interface. The quality of service of this GbE link has been successfully validated using an IP traffic tester. Thereby, almost a latency of 0.4 ms has been achieved at almost 1 Gbit/s, which meets the 5G targets.
## Tuesday, March 13, 2018

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<td>WS1: ANSYS Workshop</td>
<td>S06: Characterization and Modeling</td>
<td>S07: Antenna Components and Surface Structures</td>
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**Please note:** The exhibition will take place from 09:50-16:00.
S06: Characterization and Modeling
Chairs: Matthias Rudolph (Technical University of Brandenburg Cottbus, Germany),
Dirk Schwantuschke (Fraunhofer IAF, Germany)
Room: K9 08:30-09:50

08:30  Crosstalk Analysis and Correction in On-Wafer Measurements at WR-3 Band Frequencies
Daniel Müller¹, Florian Boes¹, Axel Tessmann², Arnulf Leuther², Thomas Zwick¹, Ingmar Kallfass³
¹Karlsruhe Institute of Technology (KIT), Germany; ²Fraunhofer IAF, Germany; ³University of Stuttgart, Germany

Crosstalk between radio frequency probes degrade the accuracy in on-wafer measurements. Although a lot of research for accounting the crosstalk influence in the calibration was published, up to now no satisfying procedure was presented. In this paper, we show how the crosstalk is affected by the change of measurement environment and present an approach, based on electromagnetic field simulations of the device under test including the probes, how the behavior can be predicted and corrected. To verify the presented concept, a 180° discrete phase shifter operating in the 200 - 330 GHz frequency range is analyzed and the crosstalk distorted measurement results successfully corrected.

08:50  Chalmers GaN HEMT Charge Model Revisited
Peng Luo¹, Frank Schnieder¹, Matthias Rudolph²
¹Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany; ²Technical University of Brandenburg Cottbus, Germany

This paper presents a charge modeling procedure based on the Chalmers GaN HEMT charge model. The impact of the transcapacitances in large-signal charge modeling is investigated. It is shown that the direct use of the determined capacitance model parameters in the charge model is impossible, for the transcapacitances caused by the two-bias-voltage dependent charges should be taken into account when the parameters are determined. Finally, it is also shown that the use of the charge model accounting for transcapacitance effects dramatically improves the Y-parameter and large-signal simulation results, which is verified by comparing the measured and simulated Y-parameters and large-signal behaviors.

09:10  Low-Frequency Dispersion and State Dependency in Modern Microwave III-V HEMTs
An AlGaN/GaN HEMT- and an InAlAs/InGaAs mHEMT technology, both with a gate-length of 100 nm, are investigated w.r.t. low-frequency dispersion and state dependency vs. average gate and drain voltages. Based on a comprehensive DC-CW and pulsed-RF small-signal characterization, it is shown that the GaN HEMT shows both effects, while the mHEMT is nearly free of state dependency. A new formulation of the recently proposed integral transform large-signal FET model is capable of describing both effects in pulsed-RF and even in CW load-pull operation conditions.

09:30  An Electronically Tuneable Inductance with Extended Frequency Range
Stefanie Loracher, Kurt Gerd Blau, Uwe Stehr and Matthias Hein
Technical University of Ilmenau, Germany

The extension of the usable frequency range of an electronically tuneable inductance circuit is investigated. By means of numerical and analytical analyses, the transistor internal reverse transfer capacitance can be identified as a frequency-limiting element, which must be minimised. This is achieved by means of circuitry-wise compensation of the capacitive effect by introducing an additional inductance. This results in an extension of the frequency range by two octaves and more, which proves beneficial for applications such as broadband matched and tuneable transmission lines, amplifier circuits, oscillators, or filters.

S07: Antenna Components and Surface Structures
Chairs: Matthias Hein (Technical University of Ilmenau, Germany), Peter Knott (Fraunhofer FHR, Germany)
Room: Runder Saal 08:30-09:30

08:30  Four Channel Waveguide Rotary Joint
Andreas Schinagl-Weiß¹, Norbert Nathrath², Michael Kilian¹, Michael Schneider¹
¹Airbus Defence and Space GmbH, Germany; ²NTP, Germany

This paper describes a four channel rotary joint. Rotary joints are key elements for steerable antennas. The developed four channel rotary joint enables the use of dual polarised signals in two different frequency bands, for example 20GHz and 30GHz.
08:50  **Self-Interference Mitigation in Full-Duplex Base-Station Using Dual Polarized Reflect-Array**

Nidal Zarifeh, Mai Alissa, Maher Khaliel and Thomas Kaiser  
*University of Duisburg-Essen, Germany*

This paper proposes the use of reflect array to mitigate self-interference in the propagation domain for full-duplex mobile communication. An ultra-wide band reflect array is considered to enable full-duplex in an indoor/outdoor LTE base-station with different users’ positions. The antenna design is customized to meet the full-duplex requirements, where two cross-polarized reflect arrays and two feeders are used to generate the uplink and downlink beams from and to half-duplex users. The paper also analyzes the components of self-interference in the direct and backscattered paths and how much of isolation can be achieved using reflect arrays in a wide band system. Both reflect array and full-duplex technologies are strong candidates to be used in 5G.

09:10  **A Miniaturized Frequency Selective Surface Sub-Reflector for X and Ku-Bands**

Safiullah Khan and Thomas F. Eibert  
*Technical University of Munich, Germany*

A metamaterial structure comprising a T-type resonator surrounded by a rectangular split ring resonator (RSRR) is periodically arranged to form a frequency selective surface (FSS). The resonances of the two different resonators and the coupling effects between them give the proposed FSS distinctive characteristics. The FSS has a single passband between two stopbands and operates in the X and Ku-bands. The analysis of the structure shows a strong incident angle and polarization stability at the resonance frequencies for the transmission coefficient. In addition, the FSS satisfies the design requirements to have insertion loss less than 0.5 dB and impedance mismatch at the harmonic frequencies. An equivalent circuit based on dual bandstop microwave filter topology is presented for better understanding of the structure. Several structures have been fabricated and measurement results are in accordance with simulated results. The presented FSSs can be used in waveguide filters, microwave absorbers, sensors and for the purpose of microwave energy harvesting.

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**PO2: Interactive Poster Session 2**

Chair: Christian Friesicke (Fraunhofer IAF, Germany)  
Room: Hall  
10:10-11:50
A Line of 4 - 40 GHz GaAs Low Noise Medium Power Amplifiers for SDH Relay Stations
Oleg Bondarev, Denis Mirvoda, Alexey Kosogor and Yuri Tikhov
Rostov-on-Don Research Institute of Radio Communication, Russia

This paper presents a line of 4-40 GHz GaAs low noise medium power amplifiers for SDH stationary relay stations with adaptive change of modulation scheme depending on jamming situation. Because of given application, broadband low noise amplifier MMICs provide also increased output power up to medium level. The line of three amplifier MMICs is optimized for noise figure performance down to 1.0-3.0 dB simultaneously with maximum output power at 1 dB gain compression point higher than 10 dBm throughout the allocated bandwidth, having gain of 20-30 dB. The chips for all three amplifiers are fabricated using a 0.15 μm GaAs pHEMT Foundry process provided by UMS.

Doherty Power Amplifier in 28 nm CMOS for 5G Applications
Ahmed Hamed, Ahmed Aref, Mohamed Elsayed and Renato Negra
RWTH Aachen University, Germany

This paper presents the design and simulation of a fully integrated Doherty power amplifier in 28 nm CMOS technology. The circuit is optimized for the frequency band 5-6 GHz achieving maximum output power of 20 dBm with 10 dB output power back-off (OBO) and 10 dB of power gain 0 dBm of input power. Drain efficiency (DE) of 35\% is obtained at OBO with almost flat response in the entire bandwidth.

Eigenvalue Analysis of a Triangular Corrugated Coaxial Cavity with Misaligned Inner Rod
Sivasubramanian Yuvaraj, Delphine Alphonsa Jose, Sukwinder Singh, Madan Singh Chauhan and Machavaram V. Kartikeyan
Indian Institute of Technology, Roorkee, India

In this paper, effect of the insert misalignment on the eigenvalue of the modes in a triangular corrugated coaxial cavity is studied. By using the Graff’s addition theorem, dispersion relation is derived for the coaxial cavity with misaligned inner rod. Analysis shows that due to the structural misalignment, superposition of the wave functions must be considered in the field equations so as to satisfy the boundary conditions. The effect of insert misalignment on the eigenvalue of the operating mode TE34;20 in 170 GHz, 2MW coaxial cavity gyrotron is studied. Results show that there is a significant modification in the eigenvalue of the mode due to the insert misalignment.
Development of a Planar Microwave Resonator Based Wetness Sensor
Oluwatosin Babarinde, Alessandra Petrocchi, Vladimir Volskiy, Ilja Ocket and Dominique Schreurs
KU Leuven, Belgium

A planar microwave device suitable for use as a wetness sensor is presented in this article. The wetness sensor is a wirelessly addressable multi-frequency resonator designed on a flexible substrate. The resonator operating between 4.5 GHz to 8.5 GHz consists essentially of six cascaded open-ended transmission lines embedded within the central conductor of a coplanar waveguide. The presence or absence of fluid on the planar microwave resonator affects its resonance frequencies. Simulations and laboratory measurements show good results demonstrating the possibility of detecting wetness using the proposed method.

A Calibration Method for Hybrid Technique Based on CMA with Clipping in MIMO-OFDM System
Rania Thabet, Wael Ali, Osama Mohamed and Darwish Mohamed
Arab Academy for Science, Technology & Maritime Transport, Egypt

Orthogonal frequency division multiplexing (OFDM) can be combined with antenna arrays to increase a system competence on time variant with the frequency selective channels which cause a multiple input multiple output (MIMO) composition. The main disadvantage of MIMO-OFDM is its high peak average power ratio (PAPR). In this paper, a hybrid technique of constant modulus algorithm (CMA) with Clipping is proposed for PAPR reduction. The proposed technique is not only improving PAPR but also improving BER. Moreover, a design of four elements UWB MIMO which satisfies the bandwidth from 3.1 to 10.6 GHz for OFDM wireless ultra-wideband (UWB) applications with a compensated channel is proposed. The performance of BER by using Rayleigh fading channel and practical channel model is improved. It has been observed that the proposed system has a better performance for PAPR reduction and BER improvement.

Simulation and Design of Koch Fractal CPW Antennas
Luis Costa, Adaildo D’Assunção and Edwin Barreto
Federal University of Rio Grande do Norte, Brazil

This paper investigates the properties of Koch fractal coplanar waveguide (CPW) antennas. New antenna geometries are proposed. Simulation is performed using HFSS Ansoft software. Results are presented for resonant frequency, bandwidth, return loss, and radiation pattern. Prototypes are fabricated and measured for comparison purpose between simulation and measurements results. Results for rectangular CPW antennas are included as well. The proposed antennas are designed to operate with
multiband in the range from 1GHz to 14GHz for CPW on FR-4 dielectric substrate layers. Consistency is observed between theoretical and experimental results.

**Compact Planar Folded Monopole Antenna with Coupling Mechanism for Quad ISM Band, GNSS and UMTS Applications**
Ali Selek, Ceyhan Turkmen and Mustafa Secmen
*University of Yasar, Turkey*

This study presents a compact meandered type monopole antenna improved with coupling mechanisms to increase the number of allocated frequency bands in consideration. The proposed antenna includes a meandered (folded) conductor structure. Two straight conductors placed at the end of the meandered part bring Industrial, Scientific and Medical (ISM) bands at the upper UHF band with coupling mechanism, and one stub-like conductor inserted at the input of the meandered region gives another ISM band at the higher frequency. The antenna works at four popular ISM frequency bands of 433, 868, 915 MHz and 2.4 GHz, which cover several wireless applications such as M-bus, M2M, IoT, LoRa, RFID, Wi-Fi and Bluetooth. Along with the optimized dimensions of meandered and straight conductor parts, the proper arrangement of the dimensions related with coplanar feed part additionally provides upper Global Navigation Satellite System (GNSS) band, which includes upper bands of GPS, GLONASS, Galileo applications, and almost full coverage of 3G/UMTS-2100/IMT-2000 band. The described antenna has compact structure with about 0.125λ₀ by 0.046λ₀ at the lowest frequency, reasonable gain and omnidirectional radiation pattern characteristics.

**Numerical Analysis of Meandered Line Based Uniform Antenna Array**
Prasetiyono Hari Mukti, Helmut Schreiber, Andreas Gruber, Helmut Paulitsch and Wolfgang Boesch
*Technical University of Graz, Austria*

Mutual coupling between antenna elements becomes an issue on development of antenna structure for compact terminal devices. In this paper, a development of antenna array structure using meander line slot is proposed. The basic antenna element of the proposed structure uses an aperture coupled based microstrip antenna with meander line structure. The proposed antenna constitutes of two substrate layers which are separated by a common ground plane. A meander line slot structure is etched to the patch element in the antenna structure to reduce the mutual coupling between adjacent elements. By using this method, it is not only reduce the mutual coupling, but also reduces the size of patch element.
**13:40 Microwave Impedance Sensors for the Dielectric Characterization of Liquids**
Aleksandar Savić, Nora Meyne and Arne F. Jacob  
*Technical University of Hamburg-Harburg, Germany*

Two small coplanar waveguide impedance sensors for the characterization of liquids are introduced. A simplified calibration procedure is developed. Placing the reference plane close to the sample yields a simple lumped element equivalent circuit model. Only two known materials, namely air and a 1.0% NaCl solution are needed for parameter extraction. The capability of the presented sensors to determine the permittivity of unknown liquids with low, moderate, and high loss up to about 12 GHz is analyzed. The major strengths of the proposed approach are broadband measurement capability, simplicity of calibration procedure and potential for miniaturization.

**14:00 Fast Dual-Synthesizer for Six-Port In-Situ Linearization in the 2.4 GHz ISM-Band**
Benedict Scheiner¹, Fabian Lurz¹, Fabian Michler¹, Stefan Lindner¹, Sarah Linz¹, Robert Weigel¹, Alexander Koelpin²  
¹University of Erlangen-Nuremberg, Germany; ²Technical University of Brandenburg Cottbus, Germany

The fourth industrial revolution requires sensors and new measuring methods in different fields. Novel six-port based techniques for measuring the resonant frequency of surface acoustic wave (SAW) sensors and calculating the underlying physical parameter from this frequency are very promising. This paper presents a fast and highly isolated radio frequency (RF) dual synthesizer in the 2.4 GHz Industrial, Scientific and Medical (ISM)-band for linearization of the six-port with several frequencies and attenuation steps which enhances the measurement results. This synthesizer is indispensable in the frequency measurement technique of resonant SAW sensors using a six-port interferometer.

**14:20 Passive Chipless Wireless Pressure Sensor for Harsh and Reflective Environments**
Peter Schumacher, Christian Schuster, Alejandro Jiménez-Sáez, Martin Schüßler and Rolf Jakoby  
*Technical University of Darmstadt, Germany*
This paper presents investigations on a passive chipless wireless pressure sensor to enhance tool life prediction in smart milling machines. High reflective environments in terms of radar clutter are investigated and benefits of using the time gating technique are discussed. Moreover, due to the proposed highly robust design, the sensor can be applied in areas with high temperatures and strong vibrations. The working principle is based on a dielectric resonator which is metal coated on its lateral surface. Perturbing the resonance mode with a metal membrane in vicinity of the resonator leads to a pressure depended resonance frequency. A broadband interrogation signal is used to determine the resonance frequency, which is represented by a notch in the backscattered spectrum. The pressure sensitivity and pressure range is configurable by using different membrane and spacer thicknesses, respectively. Furthermore, the sensor operates in the frequency range from 20 GHz to 23 GHz with read-out ranges up to 150 cm.

14:40  24 GHz RFID Transponder Frontend with an Equal Gain Baseband Combining for Industry 4.0 Applications
Bernard Lüers, Bernd Geck and Dirk Manteuffel
University of Hanover, Germany

A receiver system with an equal gain baseband combining for a sensor tag integrated in a rotating machine tool holder and operating in the 24 GHz industrial, scientific and medical band (ISM) is presented. The sensor has an easy to customize diversity receiver which guarantees a stable wireless data transfer at each position of the rotating machine tool holder, even when a non omnidirectional antenna is used. An overview is given of the operational environment for an example industry 4.0 application, of the construction and functionality of the sensor tag and of the equal gain baseband combining, which is used to combine multiple receivers. The performance of the new receiver system is evaluated and compared to a single receiver system.

15:00  An Advanced High-Temperature Stable Multipole Resonance Probe for Industry Compatible Plasma Diagnostics
Dennis Pohle1, Christian Schulz1, Moritz Oberberg1, Alexandra Serwa2, Peter Uhlig2, Peter Awakowicz1, Ilona Rolfes1
1University of Bochum, Germany; 2IMST GmbH, Germany

In this contribution the development of an advanced, high-temperature stable plasma sensor based on the multipole resonance probe (MRP) is presented. Using low temperature co-fired ceramics (LTCC) as substrate material, together with a multilayer structure, provides resistance against high temperatures as well as a sufficient mechanical stability. Therefore, the sensor is applicable as a robust measurement tool in a wide field of industrial plasma processes. The ability of the probe to determine the electron density of the plasma as well as the collision frequency of the electrons
is investigated by extensive 3D electromagnetic simulations. Measurements in a double inductively coupled plasma (DICP) reactor using different gas compositions with neutral gas temperatures exceeding 500°C confirm the suitability of the probe for a precise plasma monitoring at high temperatures.

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**S09: Integrated Circuits**

Chairs: Ingmar Kallfass (University of Stuttgart, Germany), Amelie Hagelauer (University of Erlangen-Nuremberg, Germany)

Room: Runder Saal 13:40-15:00

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**13:40**  A Highly Integrated Low-Power 400MHz RF Receiver in 0.13um CMOS for Medical Applications

Sherif Mohamed and Ghada Ibrahim

*University of Freiburg, Germany*

An ultralow-power low-IF receiver for BPSK modulated signals has been developed and fabricated in a standard 0.13-um CMOS process. The receiver offers exceptionally low power consumption whilst providing a high data rate for 402-405MHz medical implant communication service (MICS). The RF front-end consists of a differential CG-CS LNA with a positive-negative feedback technique, a frequency doubler subharmonic quadrature passive mixer driven by current input signals and loaded with a low impedance. This will minimize the LO self-mixing dc-offset and introduces a high linearity. A Novel low-power binary phase shift keying (BPSK) demodulator architecture is presented. Based on the theoretical analysis, the maximum data rate of the demodulator is derived to be 1/5th of the carrier frequency. For experimental validation, a prototype was implemented for a 4MHz down-converted signal in a low-IF receiver. The circuit occupies 680um x 530um active chip area and consumes 4.62mW power. The design achieves 31dB conversion gain and an in-band IIP3 of 3dBm. It presents a phase noise of -128dBc/Hz while the reference spur is less than -52dBc at 1MHz offset.

**14:00**  A Low Noise Figure K-Band Receiver in 130 nm CMOS

Jin Dang¹, Sebastian Brueckner¹, Joerg Schoebel¹², Achim Noculak³, Renato Negra³, Bernd Meinerzhagen¹

¹Technical University of Braunschweig, Germany; ²SF Microwave GmbH, Germany; ³RWTH Aachen University, Germany

A fully integrated K-band receiver consisting of a low noise amplifier (LNA) and a Gilbert-Mixer with DC current bleeding technique is implemented in 130 nm CMOS
technology. The input 24 GHz RF signal is down-converted to 10 MHz by a 24.01 GHz LO signal in the measurement. This receiver has a conversion gain of 21 dB for a LO power of 2 dBm. The measured input referred third order intercept (IIP3) point and 1 dB compression point are -17.9 dBm and -26 dBm, respectively. To the authors’ best knowledge this receiver has the lowest DSB noise figure of 4.6 dB compared to other published 130 nm CMOS receivers at similar RF and IF frequencies from available literature. The presented receiver consumes 29.4 mW DC power from a 1.5 V supply and has a chip area of 1.9 mm^2 including all the pads.

14:20  Investigation of Differential Broadband Amplifiers in Normally-On mHEMT Technology
Laurenz John¹, Thomas Merkle¹, Christian Friesicke¹, Axel Tessmann¹, Arnulf Leuther¹, Michael Schlechtweg¹, Thomas Zwick²
¹Fraunhofer IAF, Germany; ²Karlsruhe Institute of Technology (KIT), Germany

This paper presents differential DC-28 GHz two-stage baseband amplifier topologies realized in a 35nm gate-length InAlAs/InGaAs mHEMT technology. They are intended as key components of future single-chip receiver MMICs for point-to-point communication systems. Implementation possibilities of DC-offset cancellation and gain control without affecting the bandwidth are shown for the normally-on mHEMT technology. DC-offset levels up to ±0.2V can be compensated. The required chip area is 0.1mm^2 and the presented circuits are therefore suitable for integration in single-chip submm-wave receiver MMICs.

14:40  Mixer-based Parallel Frequency Generation in 65 nm CMOS for FBMC Transmitters
Elmira Moussavi, Oner Hanay and Renato Negra
RWTH Aachen University, Germany

This paper presents an equidistant frequency synthesizer approach for filter-bank multi-carrier (FBMC) transmitters with a targeted bandwidth of 2 GHz. The realization of such high bandwidths is a bottleneck concerning extreme high sampling speed. However, the sampling rate can be reduced through the parallelization in the FBMC transmitter. Nevertheless, the FBMC transmitter requires multiple sub-channels with a constant frequency offset. The main approach of the mixer-based topology is to generate the equidistantly spaced frequency sources. The circuit implementation utilizes a mixer-based technique which is feasible for generating 16 equidistantly spaced Intermediate Frequency (IF) signals in the range of 4 to 6 GHz with a constant frequency offset of 125 MHz. Thereby, a single reference signal at 5 GHz is used. The technique enables a minimum SFDR of around 45 dB and a great reduction in the power consumption. The results are proven by schematic and parasitic extracted post-layout simulations using TSMC 65nm CMOS technology process.
**SP3: Special Session - SFB MARIE**  
**Mobile Material Characterization and Location by Electromagnetic Sensing**  
Chairs: Ullrich Pfeiffer (University of Wuppertal, Germany), Ilona Rolfes (University of Bochum, Germany)  
Room: K2-4  
15:40-17:40

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**15:40 Simulation and Optimization of Post-Wall Waveguide Based Compact Circuits for Micro and Millimeter Waves**  
Vakhtang Jandieri¹, Daniel Erni², Hiroshi Maeda³, Arkadi Akopiani⁴  
¹General and Theoretical Electrical Engineering (ATE), Germany; ²University of Duisburg-Essen, Germany; ³Fukuoka Institute of Technology, Japan; ⁴Free University of Tbilisi, Georgia

Functional post-wall waveguide (PWW) based passive circuits are formed by introducing specific arrangements of additional posts into the PWW structure. Each arrangement represents a circuit element and consists of a circular array of cylindrical posts periodically distributed on the circumference of the corresponding ring. The circular arrays (i.e. the circuit elements) provide enough degrees of freedom to tailor the spectral response in the framework of an ultra-compact planar filter topology. The PWW circuit is analyzed using image theory in combination with the lattice sums technique yielding a highly-efficient semi-analytical computational scheme that is perfectly suitable for the numerical structural optimization of mm-wave band-pass filters. Along an exemplary study we demonstrate the feasibility of steep skirt selectivity within a device footprint of around 0.75λ².

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**16:00 Spatially Modulated High Impedance Surface Based on a Multilayer Approach**  
Benedikt Sievert, Daniel Erni and Andre Rennings  
*University of Duisburg-Essen, Germany*

This paper presents a tool box for the dimensioning and design of high impedance surfaces (HIS) with non-constant resonance frequency. An application of those surfaces is a reflector with spatial dependent phase shifting properties for creating special wave types, as spiral waves. Such types of reflectors use a spatial variation of the resonance frequency of different patches for achieving different phase shifts. When using a single layer, a large variation of resonance frequencies corresponds to a large variation of the patch geometry, i.e., patch size and gap width. This results in a coarse discretization of the desired resonance pattern when low frequencies, which correspond to large patches, are used. Instead of changing the cell size in a wide manner for reaching a desired resonance frequency, a multilayer concept, which
reduces the variation of the cell size dramatically, is going to be used. The benefit of this concept is the flexibility offered by the method. This work concentrates on the equivalent circuit representation of the structure and compares the result to numerical solutions. Furthermore, difference between an electrically thick and thin high impedance surface is investigated analytically and discussed using two equivalent circuit models. The multilayer approach has the tendency of resulting in electrically thick structures. By use of a presented rule, the designer can choose an appropriate equivalent circuit out of the given two for the design and adjust the geometrical parameters in detail using numerical simulations.

16:20 Hardware-Accelerated Embedded SAR Processor for Realtime FMCW Radar Applications
Jonas Wagner¹, Jan Barowski¹, Tobias Kalb¹, Diana Goehringer², Ilona Rolfes¹
¹University of Bochum, Germany; ²Technical University of Dresden, Germany

A realtime Synthetic Aperture Radar (SAR) imaging system for Frequency Modulated Continuous Wave (FMCW) radars using hardware acceleration for highly efficient signal processing is presented. The backprojection algorithm is used for this purpose as it combines efficiency by using the Fast Fourier Transform (FFT) for range compression and the ability to process data after each measurement. A second radar sensor provides the possibility of a free motion during the measurement process. The signal processing is implemented on a Xilinx Zynq-7000 System on a Chip (SoC). It has a processor system as well as a programmable logic that can be used for hardware acceleration of suitable functions like the FFT and the backprojection algorithm. With this system design, up to 107 measurements per second can be processed.

16:40 Chipless Tags Infrastructure Based Localization in Indoor Environments
Mohammed El-Absi¹, Ashraf Abuelhaija², Ali Al-haj Abbas¹, Feng Zheng¹, Klaus Solbach¹, Thomas Kaiser¹
¹University of Duisburg-Essen, Germany; ²Applied Science Private University, Jordan

In this work, we study dielectric resonator (DR) tag based localization using time difference of arrival (TDOA) method in indoor environments. DRs, which act as chipless tags, are used as reference nodes in order to localize an object equipped with a reader. The ringing behavior of the DR tags is utilized as the fingerprint of the tags, which is used to estimate TDOA using the cross-correlation algorithm. Simulations and measurements are performed to examine the performance of the proposed DR tags and the localization algorithm.
17:00 Investigation of the Transient EM Scattering of a Dielectric Resonator
Ali Al-haj Abbas¹, Klaus Solbach¹, Ashraf Abuelhaija²
¹University of Duisburg-Essen, Germany; ²Applied Science Private University, Jordan

Dielectric resonators have gained interest in RF identification and localization system concepts. This contribution reports observations from experiments and EM simulation with special focus on the transient behavior of the EM scattering of a ceramic resonator in free space. Explanation and analysis of the transient behavior is given using equivalent circuit modeling and EM simulation. The time constant of the particular resonant mode excited is shown to depend on the loaded quality factor of the resonant mode and governs the exponential charging up process and the exponential decay process of “ringing” of the resonator at its Eigen frequency. For an exciting RF pulse much shorter than the time constant, the resonator scattering amplitude increases linearly with increasing pulse length which allows to determine the structural response also. Forced excitation at a frequency offset from the resonant frequency will still produce free „ringing“ at the resonator’s Eigen frequency. The scattering amplitude is related to the Radar Cross Section of a dielectric resonator, but this only applies to the steady state of excitation.

17:20 Terahertz Near Field Coupling Based III-V/Silicon Hybrid Integration
Sebastian Dülme, Besher Khani, Vitaly Rymanov, Peng Lu and Andreas Stöhr
University of Duisburg-Essen, Germany

A novel compact terahertz near field coupling (NFC) based hybrid integration platform for interconnecting active III-V semiconductor devices, e.g. a high frequency photodiode (PD), with Silicon substrate is designed, simulated, and fabricated. The platform consists of an InP-based monolithic log periodic toothed antenna (LPTA)-integrated triple transit region photodiode (TTR-PD) chip as a transmitter and a second planar LPTA antenna fabricated on a highly resistive silicon (HR-Si) substrate as a receiver. The electrical THz output power of the TTR-PD is transferred using electromagnetic NFC to the receiving antenna. Numerical simulations of the novel NFC integration technique show an insertion loss IL ~ 2 dB and a return loss RL ~ 30 dB at a frequency of 250 GHz. An operating bandwidth of 45 GHz (230 GHz-275 GHz) is achieved. The angular position of the LPTA-TTR-PD chip is numerically investigated in order to minimize the polarization losses and maximize the coupling efficiency between the InP- and Si-based antennas.
S10: Microwave Tubes
Chairs: Manfred Thumm (Karlsruhe Institute of Technology (KIT), Germany), Werner Wiesbeck (Karlsruhe Institute of Technology (KIT), Germany)
Room: K9
15:40-17:40

15:40 Benefits of Advanced Full-Wave Vector Analysis Codes for the Design of High-Power Microwave Tubes
Alexander Marek¹, Konstantinos Avramidis¹, Naum Ginzburg², Stefan Illy¹, John Jelonnek¹, Jianbo Jin¹, Sergey Mishakin², Manfred Thumm¹
¹Karlsruhe Institute of Technology (KIT), Germany; ²Institute of Applied Physics of the Russian Academy of Sciences, Russia

For the design of microwave tubes, precise electromagnetic simulations of the cold structures are of particular importance. In this paper, we present the importance of full-wave vector simulations for the analysis of components in microwave tubes, particularly in high-power gyro devices. Full-wave vector simulations based on surface integral equations allow an accurate analysis of various structures. A fast solution of surface integral equations is provided by the recently developed advanced acceleration techniques. Simulations of quasi-optical mode converters in high-power gyrotrons, calculations of dispersion relations of gyrotron traveling-wave tubes with helical traveling wave structure and simulations of mirror systems are shown as examples for the wide range of applications of full wave vector simulations in the development of microwave tubes.

16:00 Considerations on the Selection of Operating Modes for Future Coaxial-Cavity Gyrotrons for DEMO
Tobias Ruess¹, Konstantinos Avramidis¹, Gerd Gantenbein¹, Stefan Illy¹, Zisis Ioannidis¹,², Parth Chandulal Kalaria¹, Martin Obermaier¹, Ioannis Pagonakis¹, Sebastian Ruess¹, Tomasz Rzesnicki¹, Manfred Thumm¹, John Jelonnek¹
¹Karlsruhe Institute of Technology (KIT), Germany; ²Technological Educational Institute of Piraeus, Greece

Gyrotrons are high-power millimeter wave sources used for electron cyclotron resonance heating and current drive (ECRH&CD) in fusion devices such as W7-X, Greifswald, Germany and ITER, Cadarache, France. Today, the fusion gyrotrons are specified to operate at around 1 MW Continuous Wave (CW) power. Future fusion reactors such as DEMO and subsequent Fusion Power Plants will require output power levels of 2 MW or even higher. At KIT, a modular 170 GHz, 2 MW TE34,19-mode coaxial-cavity gyrotron with advanced water cooling is ready for tests. The target is to achieve longer pulses in the range of 0.1-1s. The successful operation of this tube
will be a first important step towards a possible future DEMO gyrotron. Nevertheless, looking forward, there are two questions to be answered: (i) what potential does the existing cavity offer with regards to MW-class multi-frequency operation also at higher frequencies, and (ii) what could be a different mode selection to achieve an even higher output power in a more compact gyrotron design. To provide an answer to (i), based on the 170 GHz, 2 MW pre-prototype the multi-frequency operation at multiples of the resonance frequency of the diamond disc RF output window was carried out. Additionally, a slightly modified cavity design was introduced. To answer the question (ii), the TE25,22-mode was chosen and compared with the results got for the TE34,19-mode. The extreme volumetric TE25,22-mode allows to reduce the beam radius by around 25% and to increase the RF output power of the gyrotron by up to 30%.

16:20 Mode Competition Control Using Triode-Type Start-up Scenario for a 236 GHz Gyrotron for DEMO
Parth Chandulal Kalaria, Konstantinos Avramidis, Gerd Gantenbein, Stefan Illy, Ioannis Pagonakis, Manfred Thumm and John Jelonnek
Karlsruhe Institute of Technology (KIT), Germany

After ITER, the first real prototype of a fusion power plant is foreseen. It is named Demonstration Power Plant (DEMO). Within the EUROfusion work package „Heating and Current Drive“, the conceptual designs of both a hollow-cavity and coaxial-cavity gyrotron for DEMO has been suggested. For DEMO, the major target is to achieve an output power per tube which is significantly larger than 1 MW CW at an operating frequency of up to 240 GHz. In the case of the hollow-cavity gyrotron design, a very high-order TE mode (eigenvalue > 103 at a cut-off frequency of 236 GHz) is the prerequisite for the targeted high output power. At this eigenvalue range, the excitation of the desired operating mode during gyrotron start-up becomes challenging due to a large number of competing modes. In this work, it is demonstrated by numerical simulation that mode excitation and mode competition control can be significantly facilitated by using special start-up scenarios, based on a triode electron gun.

16:40 KIT In-House Manufacturing and First Operation of a 170 GHz 2 MW Longer-Pulse Coaxial-Cavity Pre-Prototype Gyrotron
Sebastian Ruess¹, Konstantinos Avramidis¹, Gerd Gantenbein¹, Zisis Ioannidis¹,², Stefan Illy¹, Parth Chandulal Kalaria¹, Thorsten Kobarg¹, Ioannis Pagonakis¹, Tobias Ruess¹, Tomasz Rzesnicki¹, Manfred Thumm¹, Jörg Weggen¹, John Jelonnek¹
¹Karlsruhe Institute of Technology (KIT), Germany; ²Technological Educational Institute of Piraeus, Greece

In frame of the work package „Heating and Current Drive“ within the HORIZON
2020 EUROfusion program the development of multi-megawatt gyrotrons for the DEMOnstration fusion power plant is ongoing at KIT. Additionally, possible future upgrades of gyrotrons for e.g. for W7-X and ITER, are under consideration. Using the KIT modular-type 170 GHz 2 MW short-pulse (ms-range) coaxial-cavity pre-prototype the superior performance of the coaxial-cavity gyrotron technology has been already demonstrated for pulse lengths of up to a few milliseconds, achieving an RF output power of 2.2 MW. This short-pulse pre-prototype is now being upgraded in two steps to allow investigation of long-pulse behavior. The first step allows pulse-lengths up to 100 ms. The second step shall allow pulse-lengths up to 1 s. The first step in the upgrade was finished just recently. Considering a multi-megawatt output power at around 50 % total efficiency of the tube, the upgrade of the pre-prototype did require significant developments in the areas of basic construction, in particular with regards to cooling technologies, and in the final assembly. In this paper, the basic construction, the manufacturing details and the assembly are shown. Additionally, it is planned to show the very first performance results of the long-pulse tube based on the measurements which will be achieved in the time frame before the conference.

17:00    RF Behavior of a 220/251.5 GHz, 2MW, Triangular Corrugated Coaxial Cavity Gyrotron Extended to the Third Operating Frequency 283 GHz
Sivasubramanian Yuvaraj¹, Delphine Alphonsa Jose¹, Madan Singh Chauhan¹, Machavaram V. Kartikeyan¹, Manfred Thumm²
¹Indian Institute of Technology, Roorkee, India; ²Karlsruhe Institute of Technology (KIT), Germany

In this paper, RF behavior studies of a 2MW triangular corrugated coaxial cavity gyrotron is presented for the operating frequency of 283 GHz to explore the possibility of multi-frequency operation in an already proposed dual regime gyrotron (220/251.5 GHz). The cavity mode for the 283 GHz operation is chosen as TE62;38. Cold cavity analysis, mode competition studies and self consistent single mode calculations are carried out for this operating frequency. Time dependent multi-mode calculations are performed to verify power growth in the desired mode and the possibility of power in the competing modes. Startup analyses are carried out using the electron beam parameters obtained from the electron gun design studies for both partial and complete space charge neutralization cases. These studies confirm that 2MW, continuous wave (CW) operation can be obtained at all the three operating frequencies (220/251.5/283 GHz) in the proposed coaxial cavity gyrotron.

17:20    Design and Simulation of CW Tunable Gyrotron Using PBG Cavity as its RF Circuit
Thottappan M and Rajanish Singh
Indian Institute of Technology, Varanasi, India
In this paper, the design and Particle-in-Cell (PIC) simulation of a THz gyrotron using Metal Photonic Band Gap (MPBG) cavity as its RF circuit for continuous wave operation in DNP/NMR is presented. The MPBG cavity is designed for the confinement of operating TE72 mode at 260 GHz. The PBG gyrotron is hot simulated for its beam wave interaction behavior using a 3D commercial PIC code. The simulation predicted a continuous wave (CW) RF output power of ~121 W at ~260 GHz in TE72 mode with a wide tunable bandwidth of ~1.5 GHz for the axial mode index 1 to 4. The magnetic field has been optimized as ~9.56 Tesla.

S11: Communication Systems
Chairs: Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany), Thomas Merkle (Fraunhofer IAF, Germany)
Room: Runder Saal 15:40-17:40

15:40   NI PXIe Based UHF RFID Reader
Manuel Ferdik, Markus Hesche, Lars-Oliver Rack, Georg Saxl and Thomas Ussmueller
University of Innsbruck, Austria

This paper presents preliminary work towards a fully functional UHF RFID reader based on the PXIe platform from National Instruments. The main part of the hardware is a PXIe-5644R transceiver module with a mounted Siemens antenna and a PXIe-8135 controller. The programming of the reader is based on LabVIEW. The system allows transmitting a Query-Command and receiving the response of a transponder. Especially for developing and implementing new functionalities within RFID systems, like additional sensor connectivity, the proposed 'open’ UHF RFID reader can be used. Rapid protocol adaptation can decrease the time to market and therefore lead to a competitive advantage.

16:00   Implementation of a MIMO Channel Emulator for Over-the-Air LTE Testing Using Software Defined Radio
Andreas Schwind, Philipp Berlt, Mario Lorenz, Christian Schneider and Matthias Hein
Technical University of Ilmenau, Germany

Recent trends in road mobility (connected cars) indicate an increasing number of on-board radio communication systems like ITS-G5 or Long Term Evolution. Due to the relation between automobiles and mobile radio communication, these complex systems need to be tested repeatably and under realistic conditions. We pursue the approach of cluster-based channel emulation, implemented in a test setup employing a commercial software-defined radio module. This paper provides an overview of the
internal structure and hardware architecture of the module Universal Software Radio Peripheral from National Instruments, describes the software implementation of the channel emulator in detail and verify results by over-the-air measurements in the virtual road simulation and test area of the Thuringian Center of Innovation in Mobility. One goal is to study the feasibility and applicability of the software-defined radio channel emulator implementation and to compare the performance with emulation by a commercial powerful communication testing device. The SDR implementation is based on a dedicated 3GPP standardized channel propagation profile. This paper augments the current research of realization of cluster-based channel emulation in anechoic chambers and their implementation on SDR modules.

16:20 Path Based MIMO Channel Model for Hybrid Beamforming Architecture Analysis
Joerg Eisenbeis, Marius Krause, Tobias Mahler, Steffen Scherr and Thomas Zwick
Karlsruhe Institute of Technology (KIT), Germany

Hybrid beamforming communication systems allow the reduction of digital channels by employing an analogue beamforming network. This approach offers a large reduction in computational effort and energy consumption. Still there are only few practical realizations of such hybrid beamforming communication systems. Hence, there is a nearly infinite number of possible implementations of such an architecture. To analyze and compare the performance of different hybrid beamforming architectures, we present a path based multiple input multiple output (MIMO) channel model. This tool allows us to generate arbitrary propagation paths with distributions of direction of departure (DOD), direction of arrival (DOA) as well as phase and amplitudes. Therefore, an insight of the channel capacity and signal-to-noise ratio (SNR) can be given for different kinds of hybrid beamforming architectures. The results show that the newly developed path based channel model is beneficial for the analysis of hybrid beamforming architectures.

16:40 Active Diplexer Layout for Rx/Tx Integrated Systems with Wide Frequency Spread
Anton Sieganschin, Thomas Jaschke, Djamschid Safi and Arne F. Jacob
Technical University of Hamburg-Harburg, Germany

This contribution deals with the performance analysis of an active diplexer for Rx/Tx integrated satellite communication antenna systems. To ensure a low noise figure of the receiver a passive diplexer with low insertion loss cascaded with a low noise amplifier (LNA) and a band-pass filter is used to separate Rx from Tx. This approach may lead to a relatively high Tx power level at the LNA input, which could even drive the latter into compression and affect the bit error rate (BER). This work analyzes the influence of phase and amplitude compression on the BER for different modulation
schemes. Two-tone measurements are performed to characterize two different commercially available low noise amplifiers. The measured results are used to analyze the performance degradation for modulation schemes that are commonly used in Satcom. Maximum power levels of the parasitic Tx signal which prevent a significant rise in the BER are inferred. This information is useful for the layout of a passive diplexer.

17:00  Aircraft Window Attenuation Measurements at 60 GHz for Wireless in-cabin Communication
Fabian Schwartau¹, Carsten Monka¹, Markus Krueckemeier¹, Joerg Schoebel¹ ²
¹Technical University of Braunschweig, Germany; ²SF Microwave GmbH, Germany

Detailed measurements at 60 GHz are carried out to measure the attenuation of an aircraft fuselage and window. The impact of different positions of the transmitter inside the aircraft is investigated. In order to put the measurements in perspective an overview of the regulatory situation and services, which may be affected by 60 GHz transmitters in an aircraft, is given.

17:20  E-Band Transceiver System Characterization Based on Bandwidth Dependent Linear Impairments
Seyyid Dilek, Parisa Harati, Eswara Rao Bammidi and Ingmar Kallfass
University of Stuttgart, Germany

This paper presents the performance analysis of a broadband wireless E-band link due to the transfer function’s bandwidth-dependent linear impairments and in-phase to quadrature channel leakage at the transceiver system. The transfer function impairments involve the gain ripple, port impedance mismatches, and group delay variations. The theoretical study of the link performance in the presence of the mentioned impairments is performed using a system-level simulation. The impairments associated with the up- and down-converting mixer and the LNA blocks are included in the simulation. To validate the theoretical analysis, the E-band link is measured in a coherent back-to-back configuration. In both the simulation and the measurement environment, the transceiver is working with a local oscillator frequency of 77 GHz. The theoretical analysis is proved through measurements. The simulation and measurement results show a good match with the relative error being less than 5% of the highest value. At an IF bandwidth of 4.75 GHz, the error vector magnitude is increased from 8% (-21.94 dB) to 22% (-13.15 dB) due to IQ channel leakage. Besides the transfer function impairments, the IQ channel leakage is investigated as an important factor on the linear impairments characterization of the broadband millimeter-wave transceiver system.
AdMOS was founded in 1997 by Dr. Thomas Gneiting and now employs nine highly qualified staff. In 2007 we moved into our own premises in the greater area of Stuttgart which are equipped with inviting and bright seminar rooms and a modern laboratory.

The AdMOS software packages for creating simulation models for CMOS transistors and other semiconductor components are in use worldwide.

Our measuring systems determine the noise of organic transistors (OLEDs) in displays of state-of-the-art mobile phones.

AdMOS supports companies to design and analyze passive components at the system, board and chip level.

We simulate and optimize our customer’s products in terms of signal integrity, electrostatic or thermal behavior and electromagnetic compatibility even before prototyping. Verification by measurements is a matter of course.

The range of applications includes complex high-speed PCB and cable connectors, high-voltage connectors for electro mobility as well as integrated circuits on microchips.
## Wednesday, March 14, 2018

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08:30  **Analysis of 4-Way Divider MMICs in GaAs Technology for H-Band Applications**  
Ana Belén Amado Rey¹, Yolanda Campos-Roca², Christian Friesicke¹, Friedbert van Raay¹, Hermann Massler¹, Arnulf Leuther¹, Oliver Ambacher¹,³  
¹Fraunhofer IAF, Germany; ²University of Extremadura, Spain; ³University of Freiburg, Germany  

A 4-way Wilkinson and a 4:1 Dolph-Chebyshev divider MMICs based on grounded coplanar waveguide technology on GaAs are presented, analyzed and compared. The Dolph-Chebyshev structure was simulated by using electromagnetic software, whereas the 4-way Wilkinson divider was simulated by a CAD tool. Both dividers are processed and experimentally evaluated for operation in H-band (220-330 GHz). The 4-way Wilkinson MMIC achieves the best insertion losses, which are lower than 1.07 dB between 235 and 255 GHz (8.2 % of relative bandwidth, RBW). Input return losses better than 12 dB, an amplitude imbalance between outer and inner branches lower than 0.7 dB and a phase difference of (1.5±0.1)° is achieved by the Dolph-Chebyshev from 235 to 257 GHz (RBW=8.9 %). The 4-way Wilkinson divider is very compact with a size of 0.09x0.22 mm².

08:50  **W-Band SPDT Switches in Planar and Tri-Gate 100-nm Gate-Length GaN-HEMT Technology**  
Fabian Thome¹, Erdin Ture¹, Peter Brückner¹, Rüdiger Quay¹, Oliver Ambacher¹,²  
¹Fraunhofer IAF, Germany; ²University of Freiburg, Germany  

This paper reports on W-band (75 GHz to 110 GHz) single-pole double-throw (SPDT) switch millimeter-wave integrated circuits (MMICs) based on a planar and a tri-gate 100-nm gate-length GaN high-electron-mobility transistor (HEMT) technology. The SPDT switches utilize the well-established quarter-wave stub topology with shunt transistors. For an improved wideband performance, an optimized layout approach is used that connects the shorted stub for the compensation of the capacitance of a shunt transistor at the center of the transistor. The presented SPDT switch MMIC demonstrates for both technology versions a measured average insertion loss of 1.3 dB over the entire W-band with a peak insertion loss of 1.2 dB and 1.1 dB in the center of the W-band for planar and tri-gate HEMTs, respectively. The one-dB bandwidth is for both MMICs almost an octave. For an input power of at least 25 dBm, both SPDT switches do not show an indication of compression.
09:10  Design of an Error Detector Circuit for BPSK Costas Loop for Carrier Synchronization in Millimeter-Wave Receivers
Eswara Rao Bammidi and Ingmar Kallfass
*University of Stuttgart, Germany*

This paper presents the system requirements for the implementation of error detector in Costas Loops for the carrier synchronization in millimeter-wave receivers. When the inputs to a circuit are baseband signals, there is a need for DC coupling, four-quadrant operation and linear processing on the signals. Based on the system requirements, a wideband DC - coupled, four - quadrant analog multiplier circuit was designed to realize an error detector in Costas Loop. The chip was designed in 130nm SiGe:BiCMOS HBT technology with ft of 250 GHz and fmax of 300 GHz. The circuit consumes a total DC power of 130 mW.

09:30  12 GHz to 40 GHz 0.13-um SiGe BiCMOS Circuits for UWB 3D Real-Time OFDM MIMO Imaging Radar Applications
Uroschanit Yodprasit\(^1\), Wolfgang Winkler\(^1\), Thomas Multerer\(^2\), Alexander R. Ganis\(^2\), Volker Ziegler\(^2\), Christian Wipf\(^3\), Matthias Wietstruck\(^3\)
\(^1\)Silicon Radar GmbH, Germany; \(^2\)Airbus Group Innovations, Germany; \(^3\)IHP - Leibniz-Institut für innovative Mikroelektronik, Germany

Ultra-wideband (UWB) circuit building blocks consisting of a low-noise amplifier (LNA), a down-conversion mixer and an up-conversion mixer have been proposed. They are dedicated for a 3D real-time OFDM MIMO imaging radar operating in a bandwidth of 12 GHz to 40 GHz. These circuits have been fabricated using IHPs 0.13-um SiGe BiCMOS technology SG13S and the measurement results are demonstrated.

09:50  A 155 GHz Low-Power Total Power Radiometer in a 130 nm SiGe Technology
Erick Aguilar, Amelie Hagelauer and Robert Weigel
*University of Erlangen-Nuremberg, Germany*

A low-power total power radiometer for passive imaging applications is presented. The radiometer is manufactured in a 130 nm SiGe technology with an ft/fmax of 250/370 GHz. The radiometer achieves a minimum noise equivalent temperature difference (NETD) of 0.32 K at 155 GHz. By optimization of the building blocks and biasing stages, a low-power system with a total power consumption of 64 mW is achieved. Due to its low NEP and low-power consumption, the system enables further integration into high-density sensor arrays for passive radiometry in the D-Band.
S13: Radar Modeling and Processing
Chairs: Frauke Steinhausen (DHBW Loerrach/ Fraunhofer IAF, Germany), Joerg Schoebel (Technische Universität Braunschweig & SF Microwave GmbH, Germany)
Room: Runder Saal 08:30-10:10

08:30  Data Rate Reduction for Chirp-Sequence Based Automotive Radars Using Compressed Sensing
Fabian Roos1, Philipp Hügler1, Christina Knill1, Nils Appenrodt2, Juergen Dickmann2
Christian Waldschmidt1
1University of Ulm, Germany; 2DAIMLER AG, Germany

For autonomous driving high-resolution radar sensors are key components, which have the drawback of high data rates. In order to reduce the amount of sampled data, random samples can be omitted and afterwards reconstructed using compressed sensing methods. A possible application is that not every receiving antenna element demands its own analog-to-digital converter. One converter can be used for several receiving elements with a random assignment to each antenna instead. In this paper, an analysis is presented of how many samples can be neglected such that a successful reconstruction in post-processing for an automotive scenario is possible. A measurement result is shown to prove that with only 40 % of samples a successful reconstruction is possible.

08:50  Virtual Interference Study for FMCW and PMCW Radar
Hans-Peter Beise, Udo Schröder and Thomas Stifter
IEE S.A., Luxembourg

Mutual interference of radar systems has been identified as one of the major challenges for future automotive radar systems. In this work the interference of frequency (FMCW) and phase modulated continuous wave (PMCW) systems is investigated by means of simulations. All twofold combinations of the aforementioned systems are considered. The interference scenario follows a typical use-case from the well-known MOre Safety for All by Radar Interference Mitigation (MOSARIM) study. The investigated radar systems operate with similar system parameters to guarantee a certain comparability, but with different waveform durations, and chirps with different slopes and different phase code sequences, respectively. Since the effects in perfect synchrony are well understood, we focus on the cases where both systems exhibit a certain asynchrony. It is shown that the energy received from interferers can cluster in certain Doppler bins in the range-Doppler plane when systems exhibit a slight asynchrony.
09:10  High-Resolution Parameter Estimation for Chirp-Sequence Radar Considering Hardware Impairments
Stephan Häfnern¹, André Dürr², Reiner S. Thomæ¹, Giovanni Del Galdo¹,³, Christian Waldschmidt²
¹Technical University of Ilmenau, Germany; ²University of Ulm, Germany; ³Fraunhofer IIS, Germany

Parametric signal processing for radar measurements is considered, in order to achieve a resolution much better than Rayleigh resolution (high resolution). Here, a chirp-sequence radar with a stretch processing receiver architecture is considered. A model describing the measurements in terms of a radar system model and a model of the transmission channel containing the target parameters is presented. According to the maximum-likelihood method, a parameter estimator is derived to infer the target parameters range and radar cross section from the measurements. The estimator in conjunction with the derived radar system model is verified using measurement data.

09:30  A Robust Real-Time Demodulation Scheme for Backscatter Transponder Based Wireless Positioning Systems
Martin Schütz and Martin Vossiek
University of Erlangen-Nuremberg, Germany

In this paper, we present a robust algorithm for demodulation and evaluation of backscatter transponder induced beat signals in wireless positioning systems. In particular, an analysis filter bank based on Goertzel filter is used for signal detection. A particle swarm optimizer controls the configuration of the filter bank and is used to measure the range of the transponder based on spectral evaluation of the beat signal with very high resolution. A Kalman-Filter is applied for optimum estimation of the range with noise suppression. An implementation and system demonstrator based on a heterogeneous FPGA and software implementation with an FMCW radar is presented to evince the proposed demodulation scheme. It allows gapless processing in chirp sequence radar systems and high output rates with high resolution and low noise.

09:50  High Precision Real-Time FMCW-Radar Signal Processing Performed on a Levitating Sphere Control Loop System
Alexander Orth¹, Timo Jaeschke¹, Lukas Piotrowsky¹, Nils Pohl¹,²
¹University of Bochum, Germany; ²Fraunhofer FHR, Germany

In this paper a brief overview of a cyber-physical demonstration system for high precision real-time FMCW-radar signal processing is presented. This system is an example for the benefits of hardware acceleration in special use cases such as FMCW-radar signal processing. To highlight the real-time capabilities a highly unstable and
nonlinear control loop system, called the levitating sphere, is chosen, where the
signal processing affects the stability by delaying positional information through the
feedback path. A signal processing chain with real-time capabilities and a processing
time of 416.9us for 1024 16-bit FMCW-radar if-data samples on a Xilinx Zynq-7030
platform is presented.

S14: Passive Components
Chairs: Andreas R. Diewald (Trier University Of Applied Sciences, Germany),
Klaus Solbach (University of Duisburg-Essen, Germany)
Room: K9 10:30-12:10

10:30 Substituting Bond Wires by Additively Manufactured
Interconnections
Konstantin Lomakin, Mark Sippel, Gerald Gold, Johannes Ringel, David Weiß, Klaus
Helmreich, Markus Ankenbrand and Jörg Franke
University of Erlangen-Nuremberg, Germany

This work shows a comparison of microstrip to integrated circuits junction between
conventional bond wires and additively manufactured signal interconnect. Therefo-
re, an approach for reducing signal reflection is proposed and imple-
mented on a
test board fabricated on typical radio frequency substrate material. Measurements
up to 24 GHz reveal improved performance as compared to conventional technology
in terms of reflection suppression and transmission losses.

10:50 Electromagnetically Coupled Coplanar Waveguide to Stripline
Transition in LTCC Technology
Akanksha Bhutani¹, Benjamin Goettel², Jonathan Mayer¹, Mario Pauli¹, Thomas
Zwick¹
¹Karlsruhe Institute of Technology (KIT), Germany; ²Wellenzahl Radar- und Sensor-
technik GmbH & Co KG, Germany

A coplanar waveguide-to-stripline signal transition based on electromagnetic cou-
pling principle is presented in this paper. The signal transition is designed in low
temperature co-fired ceramic (LTCC) technology for integration in a 122 GHz radar
System-in-Package (SiP) design. Simulation results of the signal transition, in back-to-
back configuration, show an operational bandwidth of 114.5 to 132 GHz i.e. 14.2%
relative bandwidth. A manufactured prototype of the signal transition was measured
in the frequency range of 110 to 170 GHz using coplanar waveguide probes. The
measured insertion loss is < 2 dB from 120 to 133 GHz for the single-ended transi-
tion and the measured return loss is $> 10 \text{ dB}$ from 137 to 150 GHz. X-ray images of the manufactured prototype are shown to highlight the manufacturing errors. The simulation model is modified on the basis of X-ray analysis and a good agreement between the modified simulation and the measurement result is achieved.

11:10  **Design and Characterization of a Compact and Robust Shielded Dielectric Waveguide for mmW Applications**  
Felix Distler, Daniel Oppelt, Jan Schür and Martin Vossiek  
*University of Erlangen-Nuremberg, Germany*

This paper presents a dielectric waveguide concept for mmW-frequencies. To avoid typical problems of open structure waveguides like unshielded dielectric waveguides, a compact and still flexible design is proposed. To provide experimental results, a waveguide transition for metallic rectangular to round dielectric waveguides has been designed and characterized. This approach is verified by simulation and measurement results.

11:30  **Low Reflective Aerosol Jet Printed Broadband Matched Load up to 67 GHz**  
Konstantin Lomakin, Mark Sippel, Gerald Gold, Jan Fröhlich, Klaus Helmreich, Markus Ankenbrand and Jörg Franke  
*University of Erlangen-Nuremberg, Germany*

This work presents an additively manufactured termination circuit in terms of a microstrip transmission line with gradually varying conductivity applicable up to 67GHz with an absolute reflection coefficient of less than $-10\text{ dB}$ - and even less than $-15\text{ dB}$ above 12GHz. Different load conditions and manufacturing approaches are discussed and a time domain analysis supporting the theoretical design is presented.

11:50  **Optimized Coil Design for Magnetic Local Positioning Systems**  
Markus Hehn$^1$, Martin Vossiek$^1$, Felix Dollinger$^2$, Karl Leo$^2$, Bahman Kheradmand-Boroujeni$^2$, Frank Ellinger$^2$  
$^1$*University of Erlangen-Nuremberg, Germany; $^2$Technical University of Dresden, Germany*

Wireless identification and locating systems are increasingly employed in retail, transportation and logistic applications. Because of the potential for low cost manufacturing and mechanical flexibility, transponders and RFID tags based on organic electronic are currently hot topics of intense research in order to replace expensive semiconductor circuits. However, despite major advances in this area, the operating frequency of organic circuit is still limited to the MHz range. Thus, in order to enable locatable organic transponders, advanced magnetic or RF locating concepts as well
as strategies for optimized transponder designs are needed. In this paper two essential, yet easy to use optimization criterias for TX- and RX-coil design applicable to magnetic positioning systems are derived and evaluated. An exemplary credit-card-sized planar TX-coil and a circular RX-coil are constructed, simulated and implemented. The simulation results are compared to measured values, to verify the design approach. It is shown, that the optimized coils allow for a reading range of about 10 m.

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**S15: Radar Sensors and Imaging**

Chairs: Axel Hülsmann (OndoSense, Germany), Christian Waldschmidt (University of Ulm, Germany)
Room: Runder Saal 10:30-12:10

10:30 Detection of Dry Fiber Fabric in Glass Fiber Reinforced Plastics Using a Focused W-Band Radar
Dominik Meier¹, Christian Zech¹, Benjamin Baumann¹, Axel Hülsmann², Torsten Link³, Michael Schlechtweg¹, Jutta Kühn¹, Leonhard Reindl⁴, Frauke Steinhagen¹,⁵
¹Fraunhofer IAF, Germany; ²OndoSense, Germany; ³Composite Material Supply GmbH, Germany; ⁴University of Freiburg, Germany; ⁵DHBW Lörrach, Germany

This paper describes a focused frequency modulated continuous wave (FMCW) radar operating in W-Band (75 GHz to 110 GHz) to detect dry fiber fabric in glass fiber reinforced plastic (GFRP) components. The system can provide depth and size informations of faults inside glass fiber reinforced plastics without the requirement of a coupling medium, e.g., ultrasonic sensors while providing similar results.

10:50 Multi Channel Approaches for an Automotive Synthetic Aperture Radar
Fabian Harrer¹, Florian Pfeiffer¹, Andreas Loeffler², Thomas Gisder³, Christian Buchberger⁴, Erwin Biebl⁴
¹Perisens GmbH, Germany; ²Continental, Germany; ³Volkswagen AG, Germany; ⁴Technical University of Munich, Germany

This paper presents approaches, which improve Synthetic Aperture Radar (SAR) images for automotive applications with the use of digital beamforming preprocessing of the multi channel radar data. The classical SAR modes stripmap, spotlight and squinted SAR are implemented. Additionally, the displaced phase center method is applied. The classical beamforming approach for an uniform linear array is described. Finally, the different SAR modes are presented and their improvement on the image is demonstrated using measurements of a parking lot scenario. The focus of this
paper is on the better recognition of surfaces that are not directly illuminated by the radar main beam.

11:10 Characteristics of the High-Performance Highly Digitized Multi-purpose Radar System GigaRad
Matthias Jirousek, Simon Anger, Stephan Dill, Markus Peichl, Eric Schreiber and Harald Schreiber
German Aerospace Center (DLR), Germany

In the past years DLR has developed and operates a very versatile and modular high-resolution radar system for manifold applications. The so called GigaRad instrument is an experimental system operating in X and Ku band, and can provide spatial resolution of a few centimeters. The waveform generation and reception in the baseband is performed by IQ modulation and demodulation, based on full digitization of the baseband signals in transmit and receive path. The system concept providing two transmit and two receive channels allows quasi monostatic, bistatic, or MIMO (multiple input multiple output) operation. The normal transmit waveform is a chirp, but also any other waveforms like noise or orthogonal coded signals are possible. Based on coherent system architecture and the realized degree of automation the applications of the instrument vary from RCS measurements, UAV detection to the Imaging of Satellites in Space (IoSiS). In this paper the basic system concept, the calibration procedure, and some applications of the instrument are outlined.

11:30 Prototype System for Microwave Breast Imaging: Experimental Results from Tissue Phantoms
Dennis Wörtge¹, Jochen Moll¹, Moritz Mälzer¹, Viktor Krozer¹, Frank Hübner¹, Babak Bazrafshan¹, Thomas Vogl¹, Adam Santorelli², Milica Popović³, Natalia Nikolova⁴
¹University of Frankfurt am Main, Germany; ²National University of Ireland, Galway, Republic of Ireland; ³McGill University, Canada; ⁴McMaster University, Canada

This paper presents an UWB microwave breast imaging prototype system that operates in the frequency range from 1 GHz to 9 GHz. In contrast to other microwave breast imaging systems we propose a two-dimensional scanning of the compressed breast based on UWB bowtie antennas. This approach enables a direct comparison with measurements obtained from X-ray mammography. In this work, we will describe the setup of the breast imaging system including its main components and basic signal processing steps. Qualitative imaging results are presented for a tissue mimicking phantom containing four inclusions with a small dielectric contrast. Finally, spectroscopic measurements up to 20 GHz are presented at the end of this study to characterize the material properties of the inclusions and the surrounding material.
11:50   Radar-Based Detection of Thoracoabdominal Asynchrony During Breathing Using Autocorrelation Function Analysis

Una Karahasanovic and Dimitri Tatarinov
IEE S.A., Luxembourg

During periodic breathing motion, chest and abdomen do not necessarily move in a synchronous way. A large degree of asynchrony, which can be characterized by the value of the phase lag angle between the chest and the abdominal motion, indicates the presence of certain breathing disorders, such as bronchopulmonary dysplasia, certain neuromuscular diseases or an airway obstruction. In order to detect these abnormalities and decide on the course of treatment, it is necessary to determine the value of the phase lag. We propose to use a frequency shift keying radar-based sensor which records the superposition of the radar signals originating from the chest and the abdominal regions. Using an analytical model for the chest-abdomen motion, we have shown that the degree of thoracoabdominal asynchrony can be extracted by analyzing the changes in the features of the Fourier transform of the signal autocorrelation function, as the carrier frequency is varied. Our findings are corroborated by Matlab simulations.
Workshops

Tuesday, March 13, 2018

WS1: ANSYS Workshop
Electromagnetic Simulation Auto-Radar Antennas and mmWave Sensor Systems
Room: K2-4 08:30-10:10

Markus Laudien
ANSYS Germany GmbH

Millimeterwave sensors gain a wide field of applications like for automotive radars as well as for industrial or infrastructure applications.

As the signal quality for postprocessing strongly depends on the mounting situation and the surrounding environment a prediction based on electromagnetic simulation is often very helpful. Due to the complexity of these structures both the design process as well as the electromagnetic simulation of these systems are often challenging.

Based on new simulation methods like co-simulation, FE-BI Hybrid solver techniques enhanced Shooting and Bouncing Ray (SBR+) method the simulation procedure can be strongly improved. A choice of a suitable design environment as well as appropriate solver technology can be used to efficiently solve geometries of extreme differing size.

Showing practical example cases like antenna arrays and embedded antennas the workshop will address the simulation approaches for antenna placement on larger geometries or target scenario simulation. A discussion will point out the advantages and limitation of the simulation techniques for the different applications.
WS2: Progress on Energy Efficient Devices Workshop
Room: Runder Saal  
10:10-11:50

In this workshop four speakers from different technological domains shall give a good overview on the recent progress on energy efficient device development with particular focus on RF- and power. The workshop is intended for the general audience to obtain a good overview on various aspects in a single session. A good coverage on the technology status and the challenges to be overcome is given. The topics include the progress on Silicon CMOS, SiGe HBT and BiCMOS technologies, novel GaN devices, and novel diamond devices.

The speakers include:

Energy Efficiency Enabled by Silicon CMOS Technologies
Gabriel Kittler, Liu Zhengchao, Melanie Wilhelm and Gerhard Fleischmann

One of the main driver for recent CMOS technology developments is the need for more energy efficient devices as key enabling technology for a wide variety of applications. This is not only true for mobile applications, but also for automotive and industrial applications in order to shrink the chip size and therefore the cost for complex system-on-chip (SoC) solutions. The integration of new energy efficient devices into a 0.18 µm Silicon-on-Insulator (SOI) technology will be presented. Joint optimization of on-resistance and reliability is one of the key aspects for the development phase. But energy efficiency is not limited to devices only, but is important for the whole design phase of an integrated circuit. Special low-power digital libraries are developed in this 0.18 µm SOI technology as well as a design flow supporting ultra-low power integrated SoC solutions.

High-Performance SiGe BICMOS Technology
Holger Rücker and Bernd Heinemann
IHP - Leibniz-Institut für innovative Mikroelektronik

Recent research results revealed a significant potential for the enhancement of the RF performance of SiGe HBTs. Peak $f_t$ values of 500 GHz and $f_{MAX}$ values of 700 GHz have been demonstrated in an experimental process flow. The EU project TARANTO addresses the integration of HBTs with a similar performance in BiCMOS technology platforms. These technologies will open up new design options for existing mm-wave applications such as automotive radar systems and facilitate new applications in sub-mm bands.
Novel GaN Technology Development
Peter Brückner
Fraunhofer IAF

In recent years, IAF demonstrated superior performances with DCDC-converter and high frequency GaN-technologies. In the field for power converter monolithically integrated topologies with switching frequencies up to 3 MHz could be recently developed. In addition concepts for normally off FETs and vertical device structures are currently under development and showed promising performances. At the outset, the GaN50/25 technology leads to high power and excellent efficiencies in the frequency range up to K-band. For higher frequencies, up to the W-band, the GaN10-technology with \( l_g = 100 \) nm, exhibited good performance and excellent reliability. The further reduction of the gate-length to 50 nm leads in the first development iterations to extrinsic \( f_T \)-values beyond 160 GHz which makes D- and G-band GaN-MMICs in the near future feasible.

High Power Diamond Schottky Diodes Based on Single Crystalline Diamond
Verena Zürbig, Lucas Pinti, Philipp Reinke, Lutz Kirste, Fouad Benkhelifa, Volker Cimalla and Christoph E. Nebel
Fraunhofer IAF

Single-crystalline diamond is a promising semiconductor for the fabrication of high power, high frequency and high temperature electronic devices due to its outstanding physical properties such as wide band-gap, high thermal conductivity, high breakdown electric field and high carrier mobilities. In this talk we will report on single-crystalline diamond Schottky diodes based on p-doped diamond. The fabricated Schottky diodes consist of a p-doped HPHT diamond substrate of (001)-orientation and a p-doped drift-layer. Temperature dependent IV characteristics as well as a detailed analysis of the Schottky-barrier and the ideality-factor will be given.
WS3: IEEE Electromagnetic Compatibility (EMC) Workshop
Emerging Topics in Automotive Microwave and EMC Engineering

Room: K9
10:10-11:50

Thomas Eibert¹, Christoph Wagner², Saeed Milady³, Matthias Tröscher⁴
¹Technical University of Munich; ²Rohde & Schwarz; ³NXP Semiconductors Germany GmbH; ⁴CST – Computer Simulation Technology GmbH

The Automotive Industry has seen a big technological change from primarily mechanically driven innovations to a highly complex electric and electronic system. Electromagnetic compatibility investigations have been playing an important role for many years but were mainly seen as a must-be and often pushed to the end of the product development cycle.

Antenna design and RF analysis received more attention already at an early stage of product prototyping, but research and investigations mainly concentrated on installed antenna performance rather than mutual coupling because of the different and well separated frequency bands. With the ever increasing number of antenna systems in the automobile, however, inter-systems and intra-system coupling and RF interference becomes more important and requires closer cooperation between MW & RF and EMC engineers.

This workshop has been organized in collaboration with the IEEE German EMC Chapter.
WS4: FormFactor Workshop
Automating On-Wafer THz Calibration and Verification Compared with Manual Methods
Room: K2-4 13:40-15:20

Ruben Zowada
FormFactor, Inc.

Calibration accuracy and repeatability have long been key to obtaining accurate on-wafer device models. Probe placement tolerances are more critical to calibration as operation frequency increases. Cascade Microtech have launched a range of on-wafer probes that allow testing up to 1.1 THz, a sizeable jump from our previous 500 GHz limit.

We have considered the additional requirements needed for the test cell to achieve reliable, repeatable results. For instance, 1 μm of mis-placement represents approximately 3° phase deviation at 1.1 THz. Given the tolerances involved, we felt that an automated Multiline TRL calibration would deliver the best results. With that in mind developed a large area programmable positioner to handle the combination of probe and large test head. This works in conjunction with Wincal XE™ calibration software and a semi-automatic prober running Velox™ software, allowing fully-automatic calibration after initial probe placement. However, not all engineers have access to semi-automatic stations or programmable positioners, and so we evaluated the tradeoffs involved.

The presentation will show a configuration and operation video for automatic calibration for 1.1 THz, a manual station with a programmable positioner and a fully manual setup. Error term variation on consecutive calibrations and variation of validation structure measurements will be presented and compared.
Wednesday, March 14, 2018

WS5: CST Workshop
Workshop on New Features for Microwave and RF Simulation in CST® STUDIO SUITE® 2018
Room: K2-4 08:30-10:10

Christoph Claßen, Christian Kremers
CST - Computer Simulation Technology GmbH

From the first stages of design to the final optimization, CST STUDIO SUITE is an industry-standard electromagnetic (EM) simulation tool for microwave, radio frequency and optical product design.

This workshop will highlight new features of CST STUDIO SUITE 2018 and demonstrate smooth workflows that allow components and systems to be designed, simulated, analyzed and optimized efficiently.

Different components require different simulation methods and we will show how CST tools can help companies achieve robust, integrated designs through various worked examples, including antenna array design and antenna installed performance.

Please note: All delegates have free admission to all workshops.
Conference Venue

Welcome to Freiburg!

Freiburg is a sunny, cheerful university town located at the edge of the Black Forest and near the borders with France and Switzerland. It is well-known for its historic Old Town with the medieval “Münster” and the quaint little gullies – called “Freiburger Bächle” – that line the narrow lanes. But the city is also a modern, internationally-renowned hub for business and science with a vibrant and varied cultural scene. In the last decades Freiburg has built an international reputation as the Green City. It excels in the areas of transportation, energy, waste management and land conservation creating a green economy that perpetuates even more environmental progress.

People from all over the world visit Freiburg every year and enjoy its fusion of modernity and tradition, the local Baden wine, culinary highlights and the mild climate.

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Konzerthaus Freiburg

The Konzerthaus is a concert hall designed by the Berlin architect Dietrich Bangert. It was opened to the public in 1996. Thanks to its unique atmosphere and the ample natural light, the building is not only used for concerts and performances but also for conventions, meetings, annual general meetings, workshops, as well as major social events.

The Konzerthaus Freiburg is ideally connected with the public transport system. It is only a short walk to the Freiburg Central Station which is directly opposite. The Central Bus Terminal as well as tram stops are located here. Buses and trams usually operate until midnight. Taxis are available in front of the main entrance of the Konzerthaus Freiburg.

If you arrive by car, please use the underground car parks (“Konzerthaus” and “Bahnhofsgarage”).
Room layout of Konzerthaus (2nd floor)

The sessions take place in three different rooms: K2-4, K9 and Runder Saal. The exhibition and poster sessions are located in the hall.

Industry-Sponsored Welcome Reception

All conference participants are cordially invited to attend the get-together on Monday evening from 6 to 8 p.m. The welcome reception takes place in the hall.

Enjoy the opportunity to meet colleagues and to share ideas and experiences in a convenient atmosphere.

Free WiFi Connection

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Agilent’s Electronic Measurement Group is now Keysight Technologies.
The GeMiC 2018 Conference Dinner takes place on March 13 at the VOLANTE in Kirchzarten.

Join our evening event surrounded by a private collection of unique classic cars. The VOLANTE combines museum and event location in one room. The focus of the exhibition is on the works of the French company VANVOOREN from the golden age of coachbuilding, the 1930s. Rare sports cars and milestones of automotive history with high-end vehicles complement the exhibition. With its extraordinary ambience and a restaurant that offers high-quality cuisine, the VOLANTE is a favored venue for festivities at the crossroads of France, Switzerland, and Germany.

**Address**

VOLANTE
Oberrieder Str. 6
79199 Kirchzarten

**Free Shuttle Service**

We offer a free shuttle service to the dinner location for all delegates. The buses will pick you up in front of the entrance of the Konzerthaus at about 5:45 p.m.

After the Conference Dinner you will have the opportunity to use the free shuttle service to go back to Freiburg. The buses will pick you up at the location at about 11 p.m. The estimated arrival time at Konzerthaus Freiburg is 11:30 p.m. If you want to go back to Freiburg on your own, you can take the local transport. The train station Kirchzarten is a 20-minutes-walk away.
Exhibition and Sponsors Catalog

AdMOS was founded in 1997 and is located in the greater area of Stuttgart. The AdMOS software packages for creating simulation models for CMOS transistors and other semiconductor components are in use worldwide. Moreover, AdMOS provides service to generate complex simulation libraries. Our measuring systems determine low frequency noise of a great variety of semiconductor devices. Finally, AdMOS supports companies to design and analyze high speed components at the system, board and chip level.

Anritsu Corporation has been a provider of innovative communications solutions for over 110 years. The test and measurement solutions include wireless, optical, microwave/RF, digital instruments and operations support systems, that can be used during R&D, manufacturing, installation, and maintenance of Telecom networks.

The rapid pace of innovation in high-performance electronics markets is driving the need for high-fidelity RF and microwave simulation.

ANSYS RF and microwave simulation software provides capabilities for:
- Modeling and electromagnetic simulation and design optimization of antennas, radar systems and target scenarios, filters, power amplifiers and microwave components using FEM, method of moments, transient solvers and shooting and bouncing rays (SBR+) for electrically large structures
- Harmonic balance, circuit envelope and transient simulation of circuits and systems with bidirectional link to 3-D EM models
- ANSYS software streamlines the transfer of design databases from nearly all 3D-CAD formats and third-party EDA layout tools from Cadence, Mentor, Synopsys, Zuken, Altium and others.
- Link between electromagnetic simulation and thermal and stress analysis within the ANSYS multiphysics suite
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AR Deutschland is an independent subsidiary of the American company Amplifier Research (AR). AR Deutschland offers you the entire range of solutions in the fields of EMC and RF measurement technology. In the EMC field, we have a wide range of measurement and system solutions ranging from low-cost EMC pre-compliance to fully compliant, turnkey EMC test equipment. In the area of radio communication we support you with a wide range of power amplifiers for all radio and military communication applications - from low-frequency F-band to high-frequency S-band. Our flexible and effective team of specialists with many years of experience in the fields of EMC and RF technologies will take care of you competently and personally. Our customers from all areas of the electrical sector have been trusting us and our EMC and RF measurement systems for many years. AR Deutschland also has a fully equipped service department. We take care of the products and systems of our customers throughout the entire product life cycle.

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bsw TestSystems & Consulting is a measurement solution provider for the semiconductor, electronic and telecom industry as well as research and development institutes. Our emphasis is on RF/µw techniques and high-speed digital, more specific on S-parameters, tuner measurement techniques for noise parameters and load-pull, Signal Integrity applications, DC/CV parameter extraction and contacting/fxturing solutions.

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CST develops CST STUDIO SUITE, a market-leading package of high-performance software for the simulation of EM fields in all frequency bands. CST solutions are used by leading companies across many industries, including aerospace, automotive, defense, electronics, healthcare and telecommunications. CST is part of SIMULIA, a Dassault Systèmes brand.
FormFactor is a leading provider of essential test and measurement technologies along the full IC life cycle – from characterization, modeling, reliability, and design debug, to qualification and production test. Semiconductor companies rely upon FormFactor’s products and services to accelerate profitability by optimizing device performance and advancing yield knowledge. For more information, visit www.formfactor.com.

GLOBES Elektronik is a specialized sales company in the field of RF frequency and microwave. Offices are in Heilbronn (Stuttgart), Norderstedt (Hamburg) and Germering (München). The company represents major suppliers from USA, Far East, Europe in Germany, Switzerland and Austria and other European countries. Our target is to be a full and competent service provider for our customers, having not short sighted profits but long term revenue streams and mutual benefits in mind.

Keysight Technologies Inc. (NYSE: KEYS) is the world’s leading electronic measurement company, transforming today’s measurement experience through innovations in wireless, modular, and software solutions. With its HP and Agilent legacy, Keysight delivers solutions in wireless communications, aerospace and defense and semiconductor markets with world-class platforms, software and consistent measurement science. The company’s over 9,500 employees serve customers in more than 100 countries. Keysight’s singular focus on measurement helps scientists, researchers and engineers address their toughest challenges with precision and confidence. With the help of our products and services, they are better able to deliver the breakthroughs that make a measurable difference.
LPKF Laser & Electronics AG manufactures laser systems used in electronics fabrication, the medical, automotive and photovoltaic sector. As a global leader in rapid PCB prototyping, LPKF supplies the complete production line for PCB prototypes. The Ultra-Short-Pulse Laser LPKF ProtoLaser R, the universal UV Laser LPKF ProtoLaser U4 are the premiere choice for high speed micro- and nanoscale processing e.g. for precise geometries on Teflon®, ceramic filled RF material or fired/unfired ceramics.

Mician is recognized as a leading developer of EDA EM software tools for the design and optimization of waveguide components, feed networks, horn antennas as well as horn antennas with reflectors. Mician’s µWave Wizard products combine the flexibility of fast and powerful numerical methods with an appealing and ergonomic GUI that enables flexibility and openness including CAD export formats interfacing with most mechanical design tools.

As one of the world’s leading manufacturers of Test & Measurement equipment, Rohde & Schwarz offers among others an extensive portfolio of network-, signal- and spectrum analyzers. Company’s products meet the highest quality standards thus ensuring precise and reliable measurement results. No matter whether you are looking for entry-level equipment or high-class products, Rohde & Schwarz will find the right match for your Test & Measurement needs. Visit Rohde & Schwarz at Gemic 2018.

Rosenberger is a worldwide leading manufacturer of standard and customer-specific connectivity solutions in high frequency, high voltage and fiber optic technology for applications in communication, test & measurement, automotive electronics, medical electronics, industrial electronics, data systems, aerospace engineering. Founded in 1958, more than 10,000 Rosenberger employees are engaged in development, production and sale of products and services.
SEMIC RF, established in 1986, is main supplier of ultra-high frequency products covering frequency ranges from DC to THz. We manufacture LogPer antennas from 20 MHz-9 GHz in Germany. Next to tube based & solid state high power amplifiers, frequency generation systems, switch matrices, digital receivers and frequency control units we sell frequency & timing sync systems, cost-effective real-time spectrum analyzers from 9 kHz-27 GHz and the world’s smallest signal analyzer & -generator (intuitive smartphone size up to 87 GHz). We supply micro UAS’ for governments, public authorities and police tactical applications.

TECH-INTER is a specialized service provider for RF, HF and Microwave Components and Sub-Assemblies for Industrial, Military and Space applications. Tech-Inter’s work closely with R&D department of Techniwave which are at your disposal if you need Technical Support for your RF and Microwave applications. Established in 1993, Tech-Inter offers you over 20 years of hands-on experience. Our team will be pleased to support you by defining the best solution to your needs in terms of performance, cost and delivery.

Headquartered in Beaverton, Oregon, Tektronix delivers innovative, precise and easy-to-operate test, measurement and monitoring solutions that solve problems, unlock insights and drive discovery. Tektronix has been at the forefront of the digital age for over 70 years. Join us on the journey of innovation at uk.tek.com.

Teledyne LeCroy is a leading manufacturer of advanced real-time oscilloscopes up to 100GHz bandwidth, protocol analyzers, and other test instruments that verify performance, validate compliance, and debug complex electronic systems quickly. The Company is focused on incorporating powerful tools that enhance “Time-to-Insight” to rapidly find and fix defects in electronic systems, dramatically improving time-to-market for a wide variety of applications.
Telemeter Electronic is a sales and service company and successful since 1964. We offer a wide range of electronic and mechatronic components, devices and systems. We provide detailed technical knowledge and many years of experience in a wide variety of applications. In the field of RF and microwave, we are specialized in absorbing materials, amplifiers, filters and switching systems as well as chambers and antenna measurement systems.

WISI Automotive is your partner for antenna and RF systems in automotive applications with an experience of more than 90 years. In our plants in Germany and Tunisia we develop and produce high-end products like roof antennas with innovative assembly, integrated antennas in different spaces of the vehicle, antenna harnesses, telematic systems etc. To “validate” the antennas as part of the vehicle, classical antenna measurements in our 3D-chamber and livesignal test-drives are well-established.

Please note: Photos and video recordings taken during the conference will be used for press activities and public relations.
Imprint

Conference Program of GeMiC 2018, Freiburg, Germany

Published by
Fraunhofer Institute for Applied Solid State Physics IAF
Tullastrasse 72
79108 Freiburg, Germany

Title Photography © simonwhitehurst - Fotolia.com

GeMiC 2018 is organised by

Fraunhofer IAF

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