GeMiC 2016

German Microwave Conference 2016

March 14-16, Bochum, Germany

Conference Programme

RUHR
UNIVERSITÄT
BOCHUM

RUB

Contents

Programme Overview

Monday, 14 March 2016

Time	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 03/445	ID 04/459+471 ID 04/401	Time
09:00	Registration open					Design Competition		09:00
09:20								09:20
09:40								09:40
10:00								10:00
10:20								10:20
10:40								10:40
11:00		SP1: Special Session - SatCom	S01: Terahertz and Photonics					11:00
11:20								11:20
11:40								11:40
12:00							Exhibition	12:00
12:20								12:20
12:40	PO1: Interactive Poster Session	Lunch Break			FA 7.3 - VDE/ITG Meeting	Lunch Break		12:40
13:00								13:00
13:20		Opening Session, Keynotes (HID)						13:20
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15:00								15:00
15:30	PO1	Coffee Break						15:30
16:00		S02: Tomography and Imaging	S03: Waveguide Engineering	WS1: CST Industrial Workshop	SP2: Wireless 100 Gb/s and beyond			16:00
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20:00								20:00

Tuesday, 15 March 2016

	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 03/445	ID 04/459+471 ID 04/401
08:00	Registration			WS2: CST Industrial Workshop			
08:30–09:50		S04: Microwave Sensors	S05: Power Amplifier 1		MTT/AP Chapter Meeting		Exhibition
09:50	PO2	Coffee Break					
10:10–11:50		S06: MIMO Radar and SAR	S07: Filter	WS3: Ansys Industrial Workshop		Design Competition	
11:50–12:50	PO2: Interactive Poster Session	Lunch Break			IMA Meeting		
12:50–14:00		Plenary Session, Keynotes (HID)					
14:00–15:40		S08: Radar Signal Processing	S09: Steerable Antennas	WS4: IMST Industrial Workshop		Design Competition	
15:40		Coffee Break					
16:00–17:40		S10: Integrated Circuits	S11: Microwave Tubes	SP3: Special Session - Radar Systems			
17:40	Transfer by Coach to 'Henrichshütte'						
18:15–23:15	Evening Event / Conferernce Dinner						
23:15–23:45	Transfer by Coach to Bochum City Centre						

Wednesday, 16 March 2016

	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 04/459+471	
08:00	Registration						08:00
08:30		S12: Radar and TDR Systems	S13: Electromagnetic Engineering		EUMW Team Meeting 2017		08:30
08:50							08:50
09:10							09:10
09:30							09:30
09:50							09:50
10:10		Coffee Break					10:10
10:30		S14: Power Amplifier 2	S15: Material Characterization	WS5: Intel Industrial Workshop		DFG Diskussions-Sitzung	10:30
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11:10							11:10
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12:10		Closing Session, Award Ceremony (HID)					12:10
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12:50							12:50
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13:30		Lunch Break					13:30
14:00					Doctoral School until Thursday afternoon	Meeting HF-Professors until Thursday afternoon	14:00
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14:50							14:50
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18:00							18:00

Welcome Messages

German Microwave Conference, GeMiC 2016

Ruhr-Universität Bochum, March 14-16, 2016


Ilona Rolfes


Nils Pohl


Thomas Musch


Martin Hofmann

Dear GeMiC 2016 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 Ruhr-Universität Bochum (RUB)

it is our great pleasure to welcome you to the **German Microwave Conference - GeMiC 2016**, which is held from March 14 to 16, 2016 in Bochum!

This year we are celebrating the **10th anniversary of GeMiC**!

In 2004, the “HF-Professoren-Treffen” - the national meeting of all professors doing research in the high frequency range – 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) and Nürnberg (2015).

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 2016 welcomes you with a scientific program consisting of 18 oral sessions and two poster sessions.

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

Monday - Opening Session

Prof. Dr. Herbert Zirath, Chalmers University of Technology, Gothenburg, Sweden
Design of Millimeterwave Multifunction Integrated Circuits for Data Communication and Remote Sensing Applications

Dr.-Ing. Sherif Sayed Ahmed, Rohde & Schwarz, Munich, Germany
Research Gaps in Microwave Imaging

Prof. Dr. Hermann Eul, Silicon Valley's San Jose, CA, USA
5G, RF as the Differentiator

Tuesday – Plenary Session

Prof. Dr. Fadhel Ghannouchi, University of Calgary, Canada
Advanced Doherty Based RF Transmitters for Software Defined Radio Applications

Prof. Dr. Jerome Faist, ETH Zürich, Switzerland
Terahertz Quantum Cascade Lasers: from Single Mode Operation to Frequency Combs

Wednesday – Closing Session

Prof. Dr. J.-C. Chiao, University of Texas at Arlington, USA
Miniature Wireless Implants for Diagnosis and Therapy

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 Welcome Reception** on Monday, March 14th, will give the opportunity to experience "microwaves" in hands on experiments.

The **GeMiC 2016 Conference Dinner** will take place on Tuesday, March 15th, at the industrial museum "LWL Industriemuseum Henrichshütte Hattingen", which was established in 1854. The evening will start with a sightseeing tour on different trails, where visitors can learn more about the different work processes. Then the dinner will be served in this comfortable and historical atmosphere.

Following the conference, Ph.D-students will have the chance to participate in a **doctoral school** with keynote speeches, workshops and a dinner combined with a poster session where all participants will present their research topics.

Finally, we want to express our thanks to all authors, reviewers and the Awards Team for their contributions.

We would like to thank the Local Team Heike Mollenhauer, Silke Sauer, Nicole van Rheinberg and Lisa Liebner, the organizers of the Design Competition and the Doctoral School Christoph Baer, Birk Hattenhorst, Christian Schulz and Timo Jaeschke, the International Liaison Officer Józef Modelski and the VDE Team Volker Schanz, Christina Gaußmann and Jasmin Kayadelen.

We thank the German Research Foundation (DFG) for supporting GeMiC 2016.

Moreover, we highly appreciate financial and technical support by our exhibitors and sponsors Airbus, Albatross Projects, Anritsu, Ansys, AR Europe, BSW, CCG, CST, EMCO, Fraunhofer FHR, Globes, IMST, Industrial Electronics, Intel, Keysight, Krohne Messtechnik, MiCIAN, Microwave Journal, Remcom, Rohde & Schwarz, Rosenberger, Tactron Elektronik, Teledyne Lecroy, and Telemeter Electronic. Without their support, GeMIC 2016 would not have been possible.

Finally, we wish you all a successful and interesting conference in the "Ruhrgebiet".

"Glück auf!"

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Ruhr-Universität Bochum

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Fraunhofer Institut für Hochfrequenzphysik und Radartechnik, Wachtberg

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Karlsruher Institut für Technologie

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Christoph Baer
Ruhr-Universität Bochum

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Birk Hattenhorst, Christoph Baer, Christian Schulz, Timo Jaeschke
Ruhr-Universität Bochum

Local Team

Heike Mollenhauer, Silke Sauer, Nicole van Rheinberg, Lisa Liebner,
Ruhr-Universität Bochum

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Keynote Talks

Monday – Opening Ceremony (13:20 – 15:30, Room HID)

Prof. Dr. Herbert Zirath
Chalmers University of Technology, Gothenburg, Sweden

Design of Millimeterwave Multifunction Integrated Circuits for Data Communication and Remote Sensing Applications

The transmission rate of wireless data in the mobile networks is doubling every year due to the increased usage of mobile multimedia services like streaming video, music, television, data transfer in smartphones and laptop-computers etc. This tendency will require continuously improved telecom infrastructure regarding both base-stations and the backhaul communication links. Today, the E-band (71-76, 81-86, 92-95 GHz) is employed increasingly in the networks, allowing multi Gbps data rate. In a near future however, the E-band will be crowded, and novel, higher frequency bands have to be employed as well.

Several hundred Gigahertz bandwidth is available for new communication and sensing applications just waiting to be exploited at frequencies above 100 GHz. Until now, components for making such 'THz-systems' have been too expensive, too bulky, too power hungry and nonsufficient in terms of generating enough power for communication systems. With newly developed RFIC-processes, it is now possible to design multifunctional integrated circuits, realizing a full 'frontend on a chip' at frequencies well beyond 100 GHz. Recent results from ongoing projects aiming at enabling new applications for next generation mobile infrastructure, 5G, and imaging, up to 340 GHz will be reported. So far, critical building blocks such as LNA, PA, VCO, modulator and demodulator, frequency multiplier, power detector and mixer have recently been developed, and results will be reported. Multifunction front-end circuits such as complete receive and transmit RFICs, mixed signal designs for co-integrated baseband/frontend ICs, and radiometer ICs have also been developed and will be reported as well, including the newly developed D-band frontend chipset demonstrating state-of-the-art bitrate of beyond 40 Gbps.

Herbert Zirath (M’ 86-SM’08-F’11) was born in Göteborg, Sweden, on March 20, 1955. He received the M. Sc and Ph. D. degree in electrical engineering from Chalmers University, Göteborg, Sweden, in 1980 and 1986, respectively. From 1986 to 1996 he was a researcher at the Radio and Space Science at Chalmers University, engaged in developing a GaAs and InP based HEMT technology, including devices, models and circuits. In the spring-summer 1998 he was research fellow at Caltech, Pasadena, USA, engaged in the design of MMIC frequency multipliers and Class E Power amplifiers. He is since 1996 Professor in High Speed Electronics at the Department of Microtechnology and Nanoscience, MC2, at Chalmers University. He became the head of the Microwave Electronics Laboratory 2001. At present he is leading a group of approximately 40 researchers in the area of high frequency semiconductor devices and circuits.

His main research interests include MMIC designs for wireless communication and sensor applications based on III-V, Graphene, and silicon devices. He is author/co-author of more than 530 refereed journal/conference papers, and holds 5 patents. He is research fellow at Ericsson AB, leading the development of a D-band (110-170 GHz) chipset for high data rate wireless communication. He is a cofounder of Gotmic AB, a company developing highly integrated frontend MMIC chip-sets for 60 GHz and E-band wireless communication.

Dr.-Ing. Sherif Sayed Ahmed
Rohde & Schwarz, Munich, Germany

Research Gaps in Microwave Imaging

Microwave imaging has witnessed huge progress during the last few years; thanks to the advances in the semiconductor miniaturization for both analogue as well as digital circuits. Notwithstanding the ever-increasing demands for imaging solutions serving in the industrial, security, and medical domains. Many efforts are accomplished to bring microwave imaging methods from their conventional lab environment to the real applications space. Many more methods are still yet struggling to see the light apart from the lab bench and the computer simulators. Involvements from engineering, mathematicians as well as technicians are essential to make this possible in the benefit of the general public. Monitoring this over the years, it is obvious that deep research gaps are hindering the progress of this challenging technology. This talk aims to be a first step to raise the awareness of these gaps and to inform experts about the needs to collaborate their efforts. Microwave imaging has proved to be of a great benefit to many applications and one can surely say that: *we just scratched the surface!*

Sherif S. Ahmed is with Rohde & Schwarz in Munich, Germany, where he is currently specialized in modern microwave imaging technologies. For several years, Dr. Ahmed has been working on advancing personnel screening methods for the airport security sector. His current R&D activities include: near-field microwave imaging, stand-off imaging, along with the non-destructive testing, multistatic radar, advanced signal-processing techniques and last but not least terahertz technology.

Dr. Ahmed received the B.Sc. degree with Honors in electronics and communication engineering from Cairo University, Cairo, Egypt, in 2004, the M.Sc. degree in microwave engineering from the Technische Universität München, Munich, Germany, in 2007, and the doctoral degree (Dr.-Ing) with Honors from the University of Erlangen-Nuremberg, Erlangen, Germany, in 2013. He was the recipient of the University Academic Award of the Technische Universität München in 2007, the Innovation Award of Rohde & Schwarz in 2009, and the IEEE MTT Microwave Prize Award in 2013.

Dr. Ahmed has coauthored several conference and journal papers in the topic of microwave imaging with multistatic techniques. He is also an IEEE reviewer for the Transactions on Terahertz Science and Technology and a conference co-chair of the SPIE conference on Millimetre Wave and Terahertz Sensors and Technology. **Email:** sherif.ahmed@rohde-schwarz.com

Prof. Dr. Hermann Eul
Silicon Valley's San Jose, CA, USA

5G, RF as the differentiator

The world of mobile is heading towards 5G with seven-league boots. A new is exciting landscape of technology is envisaged, many details, however, are still to be invented, technologies to be conceived that push the envelope in unprecedented ways. 5G will be the foundation for the upcoming Internet of Things, and the Internet of Things will make 5G as really vice-versa. Hence, 5G will provide speed, latency, availability, etc. that unleash new user experiences and use cases that may not even be a fiction today.

However, one thing is for sure: Almost all devices on the Internet of Things will be wirelessly connected!

Wireless connectivity will call for RF technology in each and every device. The unprecedented performance requirements will represent a new generation of inspiring challenges for the RF community – researchers and developers of RF technology make wireless communication happen for more than hundred years, so they will make 5G happen and enable differentiation opportunities for the smartest.

The keynote will outline where the industry is going and what kind of challenges need to be tackled by the RF community.

Hermann Eul is a business leader with distinguished accomplishments. His strength anchors in a rare breadth and diversification of skills. He is widely respected for his deep roots in academia and technology at one end of his spectrum. At the same time, he is operationally seasoned in running business at most senior executive levels in multi-billion-dollar corporations. He is a gifted leader who enrolls employees at all levels into aspiring goals and enables them to achieve extraordinary results. Those skills are complemented with the highest levels of customer trust he enjoys across all cultures around the planet. While being a result driven realist, he loves to solicit and conduct out-of-the-box thinking to push the envelope and to pursuance of new ways towards new horizons.

Hermann Eul received diploma in electrical engineering (Bachelors and Masters) from FH Koblenz and University of Bochum, resp., as well as a doctor's degree from the latter. The University of Hanover elected him for a full professor chair. He is a 25+ years veteran in communications and wireless industry with additional background in automotive, industry, and security – all of them now blending nicely together as we approach the age of the internet of things. In his tenure he held numerous management positions at Siemens, Infineon, and Intel, after becoming member of the executive management board at Infineon all on C-level for 10+ years.

Tuesday – Plenary Session (12:50 – 14:00, Room HID)

Prof. Dr. Fadhel Ghannouchi
University of Calgary, Canada

Advanced Doherty Based RF Transmitters for Software Defined Radio Applications

The next wave in the information revolution will consist of bringing intelligence to the information and communication technology (ICT) sector, allowing seamless and intelligent networking and communication between different users using different services and operators. This will lead to the convergence of communication technologies, aiming at the development and deployment of cooperative and ubiquitous networks that involve existing and future wireless and satellite communications systems. A critical element in enabling the convergence of different communication systems is the development of software defined radio (SDR) systems that can be used across different frequency bands and for multi-standard applications. This SDR has to be developed to support different frequency carriers and modulation schemes concurrently, in addition to being power- and spectrum-efficient, in order to be able handle high data rates, while being less energy-hungry and more environmentally friendly.

The design of power amplifiers as critical components in any SRD based communication terminal has to be considered closely together with the system architecture, in order to ensure optimal system level performances in terms of quality of signal and power efficiency. The Doherty amplifier architecture is being widely used in single–input single output (SISO) 3G and 4G base stations to enhance their power efficiency along with digital predistortion (DPD) technique to mitigate nonlinear distortion as well. With the foreseen massive deployment of LTE and LTE-A and 5G technology to support, power and interconnect the Internet of Things (IoT), concurrent multi-stream multi-antenna (MIMO) and carrier aggregated (CA) efficient transmission technologies are being considered as key enabling technologies for the next generation networks requiring the design of broadband/multi-band high efficient PAs. The Digital Doherty architecture is being considered as a viable and enabling technology to design a cost-effective and broad-band multi-branch transmitter that can deliver energy efficiency comparable to conventional Doherty amplifiers for SISO applications. Recent advances and practical realizations of advanced Doherty based transmitters will be presented and discussed.

Fadhel M. Ghannouchi is currently a professor, Alberta Innovates/Canada Research Chair and Director of the iRadio Laboratory (www.iradio.ucalgary.ca) in the Department of Electrical and Computer Engineering at the University of Calgary, Alberta. His research interests are in the areas of RF and wireless communications, nonlinear modeling of microwave devices and communications systems, design of power- and spectrum-efficient microwave amplification systems and design of SDR systems for wireless and satellite communications applications. His research has led to over 700 refereed publications and 20 US patents (5 pending), 4 books and 3 spun-off companies.

Prof. Dr. Jerome Faist
ETH Zürich, Switzerland

Terahertz Quantum Cascade Lasers: from single mode operation to frequency combs

The quantum cascade laser[1] has demonstrated the ability to provide gain over a very broad wavelength range, and has seen its operation wavelength extended to the THz almost 15 years ago[2]. These devices have demonstrated very unique properties in for high-power and single mode operation, very relevant for applications such as local oscillator sources for radio-astronomy. These devices take advantage of design features both available in the optical and microwave domain such as extractor antenna or third-order DFB extractors. We will also focus on recent developments including the demonstration of THz optical frequency combs[3] [4] based on QCL active regions. The active regions of these devices can extend their gain to more than an octave of bandwidth[4], opening the possibility of self-referencing and dual-comb spectrosocpy.

[1] J. Faist, Quantum cascade lasers, 1st ed.: Oxford University Press, 2013.
[2] R. Kohler, A. Tredicucci, F. Beltram, H. Beere, E. Linfield, A. Davies, et al., "Terahertz semiconductor-heterostructure laser," in Nature vol. 417, ed, 2002, pp. 156-159.
[3] D. Burghoff, T.-Y. Kao, N. Han, C. W. I. Chan, X. Cai, Y. Yang, et al., "Terahertz laser frequency combs," Nature Photonics, vol. 8, pp. 462-467, Jun 11 2014.
[4] M. Rösch, G. Scalari, M. Beck, and J. Faist, "Octave-spanning semiconductor laser," Nature Photonics, 2015.

Jérôme Faist obtained his Diploma and Ph.D. in Physics (1989) from EPFL (Switzerland). After working at IBM Rueschlikon in Zürich (89-91) and Bell Laboratories, Murray Hill (91-97), he was nominated full professor in the physics institute of the University of Neuchâtel (1997) and then ordinary professor in the ETH Zurich (2007). His key contribution to the development of the quantum cascade laser was recognized by a number of awards that include the IEEE/LEOAS William Streifer award (1998) the National Swiss Latsis Prize 2002. His present interests cover Quantum cascade laser frequency combs and the physics of the ultrastrong coupling regime.

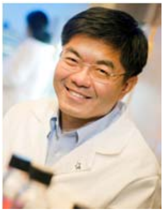
Wednesday – Closing Session (12:10 – 13:30, Room HID)

Prof. Dr. J.-C. Chiao
University of Texas at Arlington, USA

Miniature Wireless Implants for Diagnosis and Therapy

Portable electronics have made a significant impact on our society. Emerging wearable and implantable devices integrated with wireless technologies bring promising solutions for issues in the current healthcare systems. Capabilities to establish communication between body and machine, and wirelessly deliver energy into body enable comfortable and continuous monitoring of bodily functions and therapeutic modulation of tissues. Quantitative measurement and documentation of physiological and biochemical parameters allow more accurate assessment of the patients. Electronically recorded data provide better analysis for personalized medicine. Direct modification of tissues or organs by electrical signals makes it possible to manage chronic diseases with closed-loop adaptive mechanisms. With wireless communication, implants can be implemented without constrains for mobility. This increases diagnosis accuracy. Ubiquitous access to physiological information in electronic formats allows caregivers to comprehend patient’s conditions directly and with high throughput outcomes.

This presentation discusses the development of wireless micro devices in body area network systems for clinical applications. The systems are based on batteryless wireless implants with enhancements by miniature electrochemical sensors, nanoparticle modified surfaces, microelectromechanical system (MEMS) and RF communication. Several diagnosis and therapeutic treatment examples utilizing implantable wireless devices including a closed-loop system for pain recognition and inhibition, a gastro-esophageal reflux episode monitoring system and an endoscopically implantable stomach stimulator will be discussed. These applications address the implementation and cost issues in healthcare, and enable new medicines to improve human welfare and assist better living.



J.C. Chiao is Greene endowed professor and Garrett endowed professor of Electrical Engineering at University of Texas – Arlington. He received his PhD at Caltech in 1996 and was with Bellcore, University of Hawaii-Manoa and Chorum Technologies before he joined UT-Arlington in 2002.

Dr. Chiao received the 2011 O'Donnell Award in Engineering presented by The Academy of Medicine, Engineering and Science of Texas (TAMEST). He also received the Tech Titan Technology Innovator Award; Lockheed Martin Aeronautics Excellence in Engineering Teaching Award; Research in Medicine milestone award by Heroes of Healthcare; IEEE MTT Distinguished Microwave Lecturer; and IEEE Region 5 Outstanding Engineering Educator award. His webpage is at http://www.uta.edu/faculty/jcchiao/.

Sessions

Monday, 14 March 2016

Time	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 03/445	ID 04/459+471 ID 04/401
09:00–11:00	Registration open					Design Competition	
11:00–12:00		SP1: Special Session - SatCom	S01: Terahertz and Photonics			Design Competition	
12:00–12:40		SP1: Special Session - SatCom	S01: Terahertz and Photonics			Design Competition	Exhibition
12:40–13:20	PO1: Interactive Poster Session	Lunch Break	Lunch Break	Lunch Break	FA 7.3 - VDE/ITG Meeting	Lunch Break	Exhibition
13:20–15:30	PO1: Interactive Poster Session	Opening Session, Keynotes (HID)					Exhibition
15:30–16:00	PO1	Coffee Break					Exhibition
16:00–17:40		S02: Tomography and Imaging	S03: Waveguide Engineering	WS1: CST Industrial Workshop	SP2: Wireless 100 Gb/s and beyond		Exhibition
17:40–18:00		S02: Tomography and Imaging	S03: Waveguide Engineering		SP2: Wireless 100 Gb/s and beyond		Exhibition
18:00–20:00	Welcome Reception						Exhibition

SP1: Special Session - SatCom

Chairs: Arne Jacob (Technische Universität Hamburg-Harburg, Germany)
Siegfried Voigt (Deutsches Zentrum für Luft- und Raumfahrt e.V., Germany)
Room: HID Time: 11:00 – 12:40

SP1.1: High Resolution Patterning of LTCC based Microwave Structures for Q/V-Band Satellite Applications

Alexander Schulz, Nam Gutzeit, Dirk Stöpel, Tilo Welker, Matthias Hein, Jens Müller
Technische Universität Ilmenau, Germany
Time: 11:00 -11:20

Highly substrate integrated microwave circuits for space applications require a high metal pattern accuracy for transmission line structures and components. Within this work four fine line structuring processes for multilayer Low Temperature Cofired Ceramics (LTCC) are compared regarding pattern tolerances, electrical performance and process implementation capability. An embedded 60 GHz strip line filter is used as demonstrator device. The reference filter (type I) is manufactured by fine line screen printing and standard LTCC processing. Type II is based on a printed resinate layer on a prefired substrate in combination with lithography, electrodeposition and tape-on-substrate (ToS) technology. Type III and IV are made by laser ablation of printed thick film pastes in dried and fired state respectively. The latter type requires a subsequent ToS-process to embed the filter.

SP1.2: Tunable Microwave Component Technologies for SatCom-Platforms

Holger Maune, Mohammad Nikfalazar, Christian Schuster, Tobias Franke, Wenjuan Hu, Matthias Nickel, Daniel Kienemund, Ananto Eka Prasetiadi, Christian Weickhmann, Matthias Jost, Alex Wiens, Rolf Jakoby
Technische Universität Darmstadt, Germany
Time: 11:20 -11:40

Modern communication platforms require a huge amount of switched RF component banks especially made of different filters and antennas to cover all operating frequencies and bandwidth for the targeted services and application scenarios. In contrast, reconfigurable devices made of tunable components lead to a considerable reduction in complexity, size, weight, power consumption, and cost. This paper gives an overview of suitable technologies for tunable microwave components. Special attention is given to tunable components based on functional materials such as barium strontium titanate (BST) and liquid crystal (LC).

SP1.3: Integration Concepts for Miniaturized Ground Segment Satellite Antennas

Thomas Jaschke, Benjamin Rohrdantz, Hans Mitto, Arne Jacob
Technische Universität Hamburg-Harburg, Germany

Time: 11:40 -12:00

This paper discusses antenna integration concepts of combined receiver and transmitter ground terminals for Ka-band satellite communication (satcom). An analysis is carried out to determine the inherent advantages and challenges of such architectures in a satcom context. Promising dual-band and reconfigurable patch antenna designs are presented and compared to the requirements. State of the art integrated transmit and receive terminals are summarized and a promising dielectriclens based concept is introduced.

SP1.4: Active Multi-Feed Satcom Systems with GaN SSPA at K-Band

Philip Feuerschütz[1], Christian Rave[1], Stanislav Samis[1], Christian Friesicke[2], Rüdiger Quay[2], Willibald Konrath[3], Klaus Hirche[3], Dennis T. Schobert[4], Michael Schneider[4], Arne Jacob[1]
[1]Technische Universität Hamburg Harburg, Germany; [2]Fraunhofer IAF, Germany; [3]TESAT Spacecom GmbH & Co. KG, Germany; [4]Airbus DS GmbH, Germany

Time: 12:00 -12:20

The ongoing developments in antenna technology, mainly multiple-feed-per-beam (MFB) concepts, combined with advanced compound semiconductor and packaging technologies that deliver the building blocks for a new generation of K-band satellites are reported. This paper proposes a next-generation MFB application scenario exploiting the advantages of both new antenna and solid-state power amplifier concepts.

SP1.5: Modular Concept for Satcom Terminal Antennas

Matthias Geissler, Oliver Litschke, Simon Otto, Roman Gieron
IMST GmbH, Germany

Time: 12:20 -12:40

This paper describes a new modular concept for the realization of antennas for mobile satellite communications. The antenna concept is based on an active planar array, which is subdivided into modular subarrays. The antenna main beam can be steered by using a combined mechanical and electronical steering approach. The modular concept of both the aperture design as well as the beam steering allows easy tailoring of the antenna to the specific requirements of particular mobile applications like cars, trains, planes or ships.

S01: Terahertz and Photonics

Chairs: Carsten Brenner (Ruhr-Universität Bochum, Germany),
Jerome Faist (ETH Zürich, Switzerland)
Room: HIC Time: 11:00 – 12:40

S01.1: 3D Printed Waveguides for 120 GHz

Jan Balzer, Marcel Weidenbach, Stefan Busch, Martin Koch
Phillips-Universität Marburg, Germany
Time: 11:00 -11:20

In this work we investigate waveguides for 120 GHz which are fabricated by a 3D printer. We use right-angled waveguides with different length to determine the attenuation in the waveguides. Further, we analyze a Y-shaped beam splitting structure.

S01.2: Plant water status monitoring with THz-QTDS

Arno Rehn, Ralf Gente, Thorsten Probst, Jan Balzer, Martin Koch
Phillips-Universität Marburg, Germany
Time: 11:20 -11:40

We demonstrate how water status measurements on plants can be performed using terahertz quasi time domain spectroscopy (THz-QTDS). Compared with conventional THz-TDS, this approach enables much more cost-efficient measurement setups and thus brings the technology closer to it's application in the field.

S01.3: Power Budget Analysis and Optimization of Photonic Beamforming Concepts for Terahertz Transmitters

Kevin Kolpatzeck, Lars Haering, Andreas Czylwik
Universität Duisburg-Essen, Germany
Time: 11:40 -12:00

Among all concepts for beamforming in terahertz frequency transmitters, those based on a photonic approach are particularly interesting given the possibility of terahertz generation by photomixing. By moving the power distribution as well as phase and amplitude adjustment network of a photodetector-fed phased array from the electrical into the optical domain, antenna design is greatly simplified and better use can be made of the small terahertz power delivered by photomixing. However, for most effective use of the photodetectors and consequently highest RF output power, the optical input power of the photodetectors needs to be as close to their maximum power as possible. This paper presents detailed mathematical models of photonic beamforming concepts using either optical phase modulators or optical IQ modulators. A power budget analysis is carried out for both approaches and - taking into account their dynamic range and saturation behavior - most effective placement of optical amplifiers in the beamforming network is investigated. Furthermore, an approximation of the equivalent isotropically radiated power realizable with current components is given and a first look is taken at practical issues in the implementation of the proposed photonic beamforming concepts.

S01.4: Terahertz wave Generation from dual wavelength monolithic integrated Distribution Bragg Reflector semiconductor laser diode

Jared Gwaro, Carsten Brenner, Martin Hofmann
Ruhr-Universität Bochum, Germany
Time: 12:00 -12:20

THz wave generation from a dual wavelength distributed Bragg reflector (DBR) semiconductor diode laser connected by an Y-shaped waveguide with photocurrent antennas is demonstrated. Two fibre coupled photoconductive antennas were employed to generate and detect the beat frequency of the two lasers by lock in technique. Terahertz frequencies of approximately 300GHz were demonstrated via photomixing with a tuning range between 290 GHz to 320GHz.

S01.5: WGM resonators with microfluidic channel for sub-mm wave characterization of biological liquids

Alexander Barannik[1], Nickolay T. Cherpak[1], Iryna Protsenko[1], Alexey Gubin[1], Svetlana Vitusevich[2]
[1]Usikov Institute for Radiophysics and Electronics, National Academy of Sciences, Ukraine; [2]Forschungszentrum Jülich, Germany
Time: 12:20 -12:40

We present the measurement technique for studying the electromagnetic properties of small-volume water solutions of bioliquids in sub-THz band. The measurement cell is based on the quartz resonator covered by the plastic layer with the microfluidic channel filled with the liquid under test. The experimental and numerical studies of the resonator with the microfluidic channel filled with liquids with known properties were carried out to show the suitability of the resonator structure for the permittivity measurements. The resonator structure with the microfluidic channel filled with glucose and albumine water solutions was studied experimentally. The solution permittivity values can be obtained by solving of the inverse electromagnetic problem.

S02: Tomography and Imaging

Chairs: J.-C. Chiao (University of Texas at Arlington, USA),
Helmut Ermert (Ruhr-Universität Bochum, Germany)
Room: HID Time: 16:00 – 18:00

S02.1: Multiport Calibration for Microwave Tomography Systems

Marc Zimmermanns, Ilona Rolfes, Patrik Gebhardt, Malte Mallach, Thomas Musch
Ruhr-Universität Bochum, Germany
Time: 16:00 -16:20

A method for the calibration of an ultra-wideband microwave tomography system is presented. The objective for this measurement system is to calculate the spatial distribution of the dielectric parameters and thereby different materials. Scattering parameters are used to describe the setup and are given to the reconstruction algorithm for evaluation. The measured wave parameters of this system are influenced by the measurement instrument as well as by the setup itself. In addition, it is also necessary for the reconstruction to obtain the scattering parameters at a well defined reference plane. Both requirements can be achieved by the help of a multiport error correction algorithm used for the calibration of a Vector Network Analyzer (VNA). In a first step, an error model for the tomographic system is presented. Secondly, this paper provides a concept for calibration standards which can be used for this application. Since a tomographic system do not offer the possibility for the use of classic reflection standards or a change in the mechanical length of the transmission other calibration standards have to be found. The idea of a homogeneous filling of the tomograph is presented. With the help of a simulation model the requirements for the system as well as the accuracy of the results are analyzed. In addition, measurement results are shown to validate the proposed approach.

S02.2: Microwave Imaging Technique for Lung Tumour Detection

Oluwatosin Babarinde[1], Faizal Jamlos[1], Ping Jack Soh[1,2], Dominique Schreurs[2], Adalbert Beyer[3]
[1]Universiti Malaysia Perlis, Malaysia; [2]KU Leuven, Belgium; [3]Universität Duisburg-Essen, Germany
Time: 16:20 -16:40

In this work, experimental results from a study on the feasibility of detecting tumour tissue in the lung within the thorax is reported. The thorax phantom was realised using tissue simulating liquids with matching dielectric properties. The microwave images were reconstructed from the acquired backscattered signals using the delay-and-sum

imaging algorithm. The described microwave imaging technique shows that it is possible to detect tumour in the lung during breathing activities of inhalation and exhalation.

S02.3: Near-Field Measurements and Dual-Tuned Matching of Two CDRA Versions for Combined 1H/23Na 7T-MRI

Jan Taro Svejda, Daniel Erni, Andre Rennings
Universität Duisburg-Essen, Germany
Time: 16:40 -17:00

First near-field measurement results of two different congeneric dual resonant antennas (CDRAs) are presented in this paper. Each CDRA generates a half-wavelength current distribution at two desired resonance frequencies tailored to the magnetic resonance frequency of 1H- and 23Na-nuclei for 7Tesla magnetic resonance imaging (MRI). Furthermore, the dual-tuned matching and feeding networks for these antenna types are discussed and shown in this paper as well. The presented CDRAs are based on composite right/left-handed (CRLH) transmission lines terminated with open or short circuits providing two different current and field distributions between both CDRA versions.

S02.4: Towards Thermal Differential Imaging for Ultra-wideband Microwave Breast Cancer Detection

Jochen Moll, Mohamed El Houssaini, Fabian Dornuf, Viktor Krozer
Goethe Universität Frankfurt am Main, Germany
Time: 17:00 -17:20

Microwaves can be employed for biomedical applications to generate physically independent information about the biological tissue compared to conventional techniques such as X-ray, ultrasound or MRI. One challenge to increase the sensitivity of microwave diagnostics is the elimination of the high amplitude reflection that occurs at the skin surface and which masks the small amplitude reflections coming from the tumour. In this paper, we will present a novel approach for contrast enhanced microwave imaging of the breast where the temperature dependency of the biological tissue is used together with its ability to heat biological tissue. A dielectric contrast has been observed at a small temperature increase of about 1°C, similar to fever, which is enough to extract the scattering response of the tumor.

S02.5: Coupling Investigation between RF Coil Array Elements backed by Surface Impedance Characterized Shields for 7 Tesla MRI

Zhichao Chen, Klaus Solbach, Daniel Erni, Andre Rennings
Universität Duisburg-Essen, Germany
Time: 17:20 -17:40

In this paper we present a coupling investigation between RF coil array elements which are backed by surface impedance characterized RF shields for 7 Tesla magnetic resonance imaging (MRI). Two simulation models for the RF coil elements are considered here: an ideal impressed current model for an initial 2-D investigation, and a symmetrically fed dipole with meander terminals for the 3-D investigation. The RF shield, which is placed behind the coil element, is characterized by a surface impedance boundary condition (SIBC), where different surface impedances are defined. An optimal surface impedance of the RF shield can be found to achieve minimum coupling between neighboring coil elements. Different spatial arrangements (e.g. the shape of the phantom, the edge-to-edge separation between coupled coil elements, the separation from coil element to RF shield) are considered. In general, a large surface impedance provides a higher coupling level in comparison to a small surface impedance. As the separation distance from the coil element to the RF shield increases, a reduced surface impedance selectivity of the coupling behavior is observed. The proposed fundamental investigation reveals a new approach to modify the coupling characteristics of the dipole coil elements for MRI.

S02.6: Conceptualization design and simulation of a hybrid antenna system as a simultaneous RF hyperthermia applicator at 600 MHz and RF coil for magnetic resonance imaging at 3.0 Tesla

Jamal Slim[1], Dirk Heberling[1], Jörg Felder[2], Jon Shah[2]
[1]RWTH Aachen Universität, Germany; [2]Forschungszentrum Jülich, Germany
Time: 17:40 -18:00

This paper presents the conceptualization, design and simulation of a hybrid multi-frequency antenna system for Radio Frequency (RF) hyperthermia and Magnetic Resonance Imaging (MRI) applications with ultra-sharp hotspot. Two different bowtie antenna arrays have been designed, simulated and integrated. The first antenna array is designed as an RF coil for MR imaging. It is optimized to generate a highly homogeneous transmit B1+ field and is intended for 3 T MRI systems. This corresponds to a frequency of 128MHz. The second array aims to induce heat by accumulating the electromagnetic energy at one location thereby forming a hotspot. The operating frequency of the second system is 600 MHz. The computed homogeneity of the B1+ field generated by the imaging antennas shows similar values compared to a birdcage coil at the same frequency. The size of the hotspot generated by the heating subsystem was 26 x 26 x 93 mm^3. The heating produced by the MR imaging antennas was negligible, compared to the RF hyperthermia applicator.

S03: Waveguide Engineering

Chairs: Daniel Erni (Universität Duisburg-Essen, Germany),
Dirk Heberling (RWTH Aachen Universität, Germany)
Room: HIC Time: 16:00 – 18:00

S03.1: Analysis of Composite Materials with Periodically Aligned Inclusions Using 3D EM Field Simulations

Christoph Baer[1], Birk Hattenhorst[1], Christian Schulz[1], Bianca Will[2], Ilona Rolfes[1], Thomas Musch[1]
[1]Ruhr-Universität Bochum, Germany; [2]Fachhochschule Südwestfalen, Germany
Time: 16:00 -16:20

In this contribution, the effective permittivity of material compositions with special focus on the influence of periodically aligned inclusions is investigated. Therefore, several electromagnetic simulations on the material under test (MUT), which consists of a homogeneous host material and numerous spherical inclusions, are performed. By means of a rectangular waveguide setup, FDTD-simulations, and accurate permittivity determination algorithms, the MUT's effective, complex permittivity is investigated over a broad frequency range. Moreover, the results of materials with periodically aligned inclusions are compared to materials with fully randomized inclusions that exhibit equal material parameters. Detailed information on the investigation procedure as well as comparisons to theoretical permittivity values, calculated by common mixing equations, are presented and discussed.

S03.2: Modeling and Design of Stepped Transitions for Substrate-Integrated Waveguides

Thomas Jaschke, Benjamin Rohrdantz, Wanja Gitzel, Arne F Jacob
Technische Universität Hamburg-Harburg, Germany
Time: 16:20 -16:40

A stepped transition in substrate-integrated waveguide (SIW) technology is presented. The transition changes the height of an SIW using multiple steps. The steps can be tuned by varying the length of shorted stubs which represents a generalization of a stepped-impedance-transformer. An accurate equivalent circuit model of the steps is developed, that enables fast optimization. An exemplary transition is designed that features two frequency bands at 20 GHz and 30 GHz. For verification the model is compared to full-wave simulations and a back-to-back coplanar-waveguide (CPW) to full-height SIW transition is fabricated and measured.

S03.3: An Efficient Approach for Reflectivity and Coupling Computation in an Abruptly Ended Planar Layered Waveguide Using Modified Formulation of CGF-RFFM

Abdorreza Torabi, Amir Ahmad Shishegar
Sharif University of Technology, Iran
Time: 16:40 -17:00

An efficient method for computation of surface wave (SW) reflectivity and coupling in an abruptly ended planar layered waveguide is presented. Using characteristic Green's function (CGF) technique, the original structure is approximated by a separable structure. Then by applying rational function fitting method (RFFM) a uniform and closed-form expression of spatial Green's function for separable structure is derived. Having a full wave solution of the original structure, an optimization problem is defined to find the reflection coefficients of SW modes. Unlike the previous presented CGF based method called CGF-complex images (CI), CGF-RFFM leads to easy incorporation of radiation modes effects in the optimization step and more accurate results consequently. The CGF-RFFM derivation is also modified to incorporate the coupling matrix of SWs to obtain the coupling coefficients. Simple implementation, high accuracy as well as generality of the method are the main advantages of the proposed method. Excellent agreements with rigorous methods are illustrated in several examples.

S03.4: Eigenmodes of partially filled coaxial waveguides

Carsten Monka, Jörg Schöbel
Technische Universität Braunschweig, Germany
Time: 17:00 -17:20

In this paper, we present the derivation of the rotationally symmetric TM Eigenmodes (n=0) of a coaxial waveguide partially filled with a dielectric. If kp1 is element of the imaginary numbers and larger than 0 there is one solution to the waveguide's characteristic equation which provides the fundamental TM mode. Higher order TM modes follow for solutions where kp1 is element of the real numbers and larger than zero.

S03.5: Electrical Biasing Scheme for Liquid-Crystal-Based Tunable Substrate Integrated Waveguide Structures

Ananto Eka Prasetiadi, Sabrina Rahmawati, Christian Weickhmann, Matthias Nickel, Matthias Jost, Tobias Franke, Wenjuan Hu, Holger Maune, Rolf Jakoby
Technische Universität Darmstadt, Germany
Time: 17:20 -17:40

In this paper, an electrical biasing structure is proposed for a tunable Substrate Integrated Waveguide (SIW) device with Liquid Crystal (LC) as the tuning component. The biasing circuits or electrodes are made of chromium and gold layers. Silicon nitride layer, which has a thickness of 1 µm, is employed to isolate the electrodes against ground. Since voltage as high as ±200 V may be applied, high breakdown voltages are required. As a proof of concept, a simple LC-SIW phase shifter based on a tunable delay line is manufactured and sealed with the fabricated biasing structure. Simulation results exhibit a Figure of Merit (FoM) of 89 °/dB at 20 GHz. The measurements are not finished yet, but will be presented in the final paper.

S03.6: Comparison of hollow waveguide and dielectric fibre based SPDT switches for W-band

Matthias Jost, Roland Reese, Joshua Pauls, Jay Gautam, Romain Gemble, Christian Weickhmann, Onur H. Karabey, Rolf Jakoby
Technische Universität Darmstadt, Germany
Time: 17:40 -18:00

This work presents as a first approach, the comparison of two non-tuneable/switchable W-band single pole double throws (SPDTs), one realised in hollow waveguide and one in subwavelength dielectric fibre technology. For pre-investigations, both SPDTs are equipped with non-tuneable phase shifters, providing a fixed differential phase shift of 90° between the two paths. The waveguide SPDT shows a reflection better than -10 dB and an isolation between the two output ports of around 16 dB. The fibre SPDT shows reflections better than -10 dB over a wide frequency range and down to -25 dB at 100 GHz, but an isolation between 4 dB to 10 dB only. This deviation compared to simulations is due to the sensitivity of the system in terms of fabrication tolerances whereby the needed differential phase shift of 90° has been exceeded. Next, these phase shifters will be replaced by continuously tuneable phase shifters based on liquid crystal technology. At this point, dielectric fibres are a very promising alternative to hollow waveguides.

SP2: Special Session - Wireless 100 Gb/s and beyond

Chairs: Rolf Kraemer (IHP Microelectronics, Frankfurt/Oder, Germany),
Martin Vossiek (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)
Room: ID 03/471 Time: 16:00 – 18:00

SP2.1: A DC to 10.1 GHz, 31 dB Gain Range Control, Digital Programmable Gain Amplifier

Xuan-Quang Du, Markus Groezing, Matthias Buck, Manfred Berroth
Universität Stuttgart, Germany
Time: 16:00 -16:20

A fully-differential, digital programmable gain amplifier (PGA) with a gain control range of 31 dB and step size of 1 dB is presented. The chip is fabricated in a 0.13 µm BiCMOS technology and consumes 284 mW. At a maximum gain of 25 dB, the PGA exhibits a 3-dB bandwidth of 10.1 GHz. The measured gain error for all 32 possible gain settings is between -0.19/+0.46 dB at 1 GHz. Up to 13 GHz the third harmonic distortion HD3 stays below -34 dB for all 32 gain settings at a differential output peak-to-peak voltage of 1 V after the last amplifier stage.

SP2.2: Multiple-Feed On-Chip Antennas for 100 Gbit/s Wireless Systems

Benjamin Goettel[1], Stefan Malz[2], Ullrich Pfeiffer[2], Thomas Zwick[1]
[1]Karlsruhe Institute of Technology, Germany; [2]Universität Wuppertal, Germany
Time: 16:20 -16:40

One of many promising applications for silicon-MMICs is a short range, highspeed wireless data transmission of up to 100 Gbit/s. A high carrier frequency above 200 GHz can be used to achieve an ultra-compact radio module with high data rates using a high absolute bandwidth of 25-40 GHz, while keeping the relative bandwidth moderate (10-15 %). In this work different possibilities for active multiple feed on-chip antennas for an efficient power-combining of several amplifiers at millimeter-wave (mm-wave) frequencies are investigated. Therefore the on-chip antennas and power splitters are considered in detail and verified by calibrated gain measurements up to 325 GHz. The MMIC integration of on-chip antennas including several amplifiers is additionally presented for different antenna topologies. The decreasing emitter areas (SiGe) or gate lengths (GaAs) at mm-wave frequencies are the reason for the limited output power of transistors. The most common power-combining concept is the parallelization of several amplifiers with adequate splitter and combiner networks. If each parallelized amplifier saturates, the output power can be theoretically increased by 3 dB by doubling the number of amplifiers. However, the backend processes of semiconductor technologies offer high losses which makes low loss combiner networks as depicted in Fig. 1 left difficult to realize. A second approach is the use of an antenna array where each antenna element is directly connected to an amplifier. In this case, the power-combination in air offers the disadvantage to use more antennas which increases the overall chip size. With the proposed active antenna and it's concentrated phase center it can be used as primary radiator for an integrated lens antenna (ILA) which offers one of the most efficient approaches for on-chip radiators.

SP2.3: Broadband W-Band Power Amplifier using 40 nm bulk CMOS

Tung Tran, Sönke Vehring and Yaoshun Ding, Amin Hamidian, Georg Boeck
Technische Universität Berlin, Germany
Time: 16:40 -17:00

In this paper the design and measurement of a four stage broadband differential power amplifier intended for W-Band using 40 nm bulk CMOS is presented. In order to achieve broadband performance a complex output matching network consisting of transmission line elements and transformers is employed. Furthermore a reliable technique that includes neutralized transistor cores is introduced. The transistor dimension and matching network are optimized for the best compromise between bandwidth, output power and power-added-efficiency. Measurements show broadband characteristic from 75 GHz until 110 GHz with more than 10 dBm of output power and 10 % of power-added-efficiency at 1.1 V supply voltage.

SP2.4: Evaluation of a Compact Antenna Concept for UWB Massive MIMO

Dirk Manteuffel, Peter A. Hoeher, Niklas Doose
Universität Kiel, Germany
Time: 17:00 -17:20

A compact antenna concept for ultra wideband massive MIMO is proposed and evaluated. The concept is based on the simultaneous excitation of different Characteristic Modes on each element of the multi element antenna. Thereby, a 484 port antenna with low port to port correlation having only 121 physical antenna elements is generated. Its performance for MIMO systems is evaluated by link-level capacity simulations.

SP2.5: A Wideband Phase Detector SiGe HBT MMIC for Multi-Gigabit Synchronous Receivers

Aleksey Dyskin[1], Parisa Harati[3], Daniel Müller[2], Tobias Messinger[3], Ingmar Kallfass[3]
[1]Technion - Israel Institute of Technology, Israel; [2]Karlsruhe Institute of Technology, Germany; [3]Universität Stuttgart, Germany
Time: 17:20 -17:40

This paper reports a phase detector MMIC operating in the frequency range of DC to 40 GHz, with an average power conversion gain of 11 dB with wideband input matching. The MMIC is realized in 0.25 µm SiGe HBT technology. The phase detector is dedicated to form a Costas loop for broadband binary phase shift keyed signals.

SP2.6: Distributed On-Chip Antennas to Increase System Bandwidth at 180GHz

Ronny Hahnel, Bernhard Klein, Christoph Hammerschmidt, Dirk Plettemeier, Paolo Valerio Testa, Frank Ellinger
Technische Universität Dresden, Germany
Time: 17:40 -18:00

This paper presents integrated, distributed on-chip antennas. The aim is to achieve a higher system bandwidth due to the utilization of multiple antennas and the combining of their frequency ranges. All designs will be manufactured in the 130nm IHP SG13G2 process. Furthermore the measurement setup is described and measurement results are shown.

PO1: Interactive Poster Session 1

Chair: Nils Pohl (Fraunhofer FHR, Germany)
Room: Foyer
Time: 12:40 – 13:20 and 15:30 – 16:00

PO1.1: A Multisection Ultra Wideband Directional Coupler in Multilayer Broadside Coupled Stripline Technology

David-Benjamin Grys[1], Robert Storch[2], Thomas Musch[1]
[1]Ruhr-Universität Bochum, Germany; [2]Krohne Innovation GmbH, Germany

In this paper, we present a multisection directional coupler providing tight coupling of 10 dB with a ripple of 0.8 dB across the frequency range of 360 MHz to 5.8 GHz, which corresponds to a relative bandwidth of more than 4 octaves. The coupler is manufactured in a multilayer broadside coupled stripline technology and connected via standard SMA-connectors through a stripline to microstrip transition. The design process is verified by EM simulations and measurements performed on a prototype.

PO1.2: Monitoring of Low Pressure Plasmas with a Calibrated Probe

Jan Runkel, Christian Schulz, Moritz Oberberg, Peter Awakowicz, Ilona Rolfes
Ruhr-Universität Bochum, Germany

In this contribution the use of the planar multipole resonance probe (pMRP) as a monitoring tool for low pressure plasmas is presented. By 3D electromagnetic simulations, the probe's ability to monitor two important plasma parameters is investigated and a full one-port calibration is applied to ensure maximum monitoring precision. Measurements in a double inductively coupled argon plasma confirm the simulation results and prove the suitability of the calibrated pMRP for precise plasma monitoring.

PO1.3: An Enhanced Super-Resolution Wavefront Extraction Algorithm for Wideband FMCW Radar Systems

Benedikt Friederich, Dilyan Damyanov, Thorsten Schultze, Ingolf Willms
Universität Duisburg-Essen, Germany

Wideband radar analysis provides a high range resolution, which is important for ranging and material analysis. Two overlapping pulses of possible neighboring targets could disturb the ranging and the material characterization. This, takes on greater significance for Radar systems that are able to penetrate lossy dielectric materials to perform subsurface imaging and material characterization. Therefore, a preprocessing

of the received raw data is necessary in order to distinguish overlapping impulses. Conventional pulse separation methods, i.e. correlation based algorithms based on CLEAN [1] and constant false alarm rate (CFAR) algorithm can find multiple wavefronts, but these methods can not resolve richly interfered pulses. Hence, these methods are not suitable for super-resolution applications. The dynamic correlation method (DCM) was introduced in [2] as super-resolution algorithm for the separation of multiple wavefronts. Due to the complexity of this algorithm, the number of detected wavefronts is limited. For FMCWRadar the amplitude of interfered pulses has to be considered. The introduced algorithm combines the advantages of the conventional separation method and the super-resolution ability of DCM. Therefore, non-interfered pulses are clustered and each cluster is examined by an amplitude dynamic correlation method (ADCM). Furthermore, this enhancement of DCM considers different amplitudes levels of interfered pulses. The validation of the ADCM is carried out based on measurement of a complex scattering environment with 4 targets.

PO1.4: Miniaturized Broadband Three-Way Power Divider with 120° Phase Differences between Output Ports

Hitoshi Hayashi
Sophia University, Japan

This paper presents a miniaturized broadband three-way power divider with 120° phase differences between output ports. The divider is developed by using a cascade connection of 90° Lange couplers and is implemented on an FR4 substrate. For the frequency range of 440-770 MHz, which corresponds to the relative bandwidth of more than 54%, the divider exhibits power splits of −5.3 ± 0.6 dB, return losses greater than 20 dB, and isolation between output ports greater than 19 dB. Furthermore, for the frequency range of 560-580 MHz, the divider exhibits errors in the desired relative-phase difference between output ports less than 4°. The measurement results reveal the feasibility of the proposed power divider configuration for broadband circuit applications with the output ports located well away from each other, and effectively reducing transmitter intermodulation owing to their optimized structures and inner-layer crossovers.

PO1.5: Passive alignment of an optical fiber on a multi-layer ceramic module for radio-over-fiber applications

Sumy Mathew, Tilo Welker, Nam Gutzeit, Steffen Spira, Ralf Stephan, Jens Müller, Matthias Hein
Technische Universität Ilmenau, Germany

The low-temperature co-fired ceramics technology is a successful and space-qualified technology enabling three-dimensional microwave design. Now we are pursuing an important step further towards multi-functional multi-purpose hybrid assembly technologies: combining ceramic technology with optical fiber technology. In a photonics-assisted system, fiber alignment is a crucial issue. Extra gadgets used for the fiber alignment make the system more complex and bulky. Considering the many features offered by the ceramic multi-layer technology for size reduction, it is advantageous to use this technology for the passive alignment of optical fiber above the optical source. In this paper, the passive alignment of fiber employing flip-chip mounting of a vertical cavity surface emitting laser in a ceramic substrate are presented. We have studied the performance of the resulting optical link with respect to figures typical for radio-over-fiber applications, namely the link gain, noise figure and the spurious-free dynamic range and compared the results with a link where the VCSEL is wire bonded to the circuit.

PO1.6: Advanced receiver testing in a high volume environment using pogo X-talk

Stephan Fuchs[1], Robert Weigel[2]
[1]Intel Deutschland GmbH, Germany; [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Because of the rapid development of cellular technologies towards highly integrated multimode transceivers capable of worldwide interoperability in multiple frequency bands, more and more receiver bands as well as receiver ports are integrated in a single silicon device. For ensuring highest quality standards in customer delivery, accurate testing and characterization of all these ports is essential. However, the high volume testing becomes increasingly more time consuming due to the number of ports and the respective load board design. This paper demonstrates a feasible way to increase throughput by higher multisite efficiency with sharing one internal RF-source by using pogo X-talk.

PO1.7: Microwave-Photonic Filters

Stefan Preussler[1], Avi Zadok[2], Yoni Stern[2], Thomas Schneider[1]
[1]Technische Universität Braunschweig, Germany; [2]Bar-Ilan University, Israel

Microwave-photonic filters (MPF) can overcome the limitations of electrically implemented counterparts. MPF can have a very broad bandwidth, they are tunable and even the filter shape can be changed by programming. Here we review our recent results in the implementation of MPF. The filters are based on a delay-and-sum architecture or on a shaping of the gain bandwidth of stimulated Brillouin scattering.

All presented setups are tunable in their filter shape, central wavelength and bandwidth.

PO1.8: Design of Wide-Band Corrugated Feed Horn for Reflector Antenna in Radar Applications

Alexander Haas, Markus Peichl, Simon Anger
Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany

DLR - Microwaves and Radar Institute - is currently developing a new high-resolution radar system for the imaging of satellites in orbits up to 1000 km. In order to apply the principle of inverse synthetic aperture radar imaging the system uses a steerable Cassegrain antenna and a possible operational frequency range between 8 GHz to 12.4 GHz. This paper shall give a short introduction considering the basic steps in the development of a wide-band corrugated horn antenna as feed for the Cassegrain antenna system, providing similar beam width in E and H plane.

PO1.9: Next Generation mm-Wave Wireless Backhaul Based on LOS MIMO Links

Darko Cvetkovski[1], Tim Haelsig[2], Berthold Lankl[2], Eckhard Grass[1,3]
[1]Humboldt-Universität Berlin, Germany; [2]University of Federal Armed Forces Munich, Germany; [3]IHP, Germany

With the rapid growth of mobile data traffic at a projected global compound annual growth rate (CAGR) of 45% in the next 5-year period [1], wireless networks have to constantly enhance to meet the user's demands. For the next generation of wireless networks, very high densification (especially in urban areas) will be one of the key features in order to achieve the envisioned low-latencies and high-throughputs [2]. The vast deployment of small cells is essential as the areal traffic density in the upcoming 5G network is expected to amount up to an astounding 750 Gbps=km2 [3]. One of the major bottlenecks in the network densification is the backhaul network. Existing backhaul solutions are either based on wired communication links such as fiber optics, widely utilized for their high capacity, or wireless links operating dominantly in the microwave frequency range. However, the bandwidth limitation and high operating costs of the former limit their applicability in the evolution of the backhaul networks. Seeking for a long term small cell solution that is both cost-efficient and flexible in its' deployment, in this paper we will focus on wireless backhaul at the millimeter wave (mm-wave) frequency range, i.e. 30 GHz to 300 GHz, as it offers sufficiently high bandwidths to achieve the required throughput.

PO1.10: Application of Selected Performance Test Scenarios on Multi-channel UHF Receivers

Ralph Trommer, Philipp Quednau, Lorenz-Peter Schmidt
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

In a preceding paper a multi-channel test signal generator for UHF radar applications was presented. The present contribution shows the application of this generator to test the performance of multi-channel receivers in selected scenarios. Exemplary measurement results are presented showing the usable dynamic range and the maximum packet reception rate for a secondary surveillance radar receiver and a smart meter data collector. Furthermore the direction-of-arrival estimation precision and the source separation capabilities of the receivers are tested under various conditions.

PO1.11: Synthesis and Design of Narrowband Bandpass Filters in Waveguide Technique

Stefan Reible, Reinhold Herschel, Ralf Brauns, Dirk Nüßler, Nils Pohl
Fraunhofer FHR, Germany

The design and realisation of a high order bandpass filter in the millimetre wavelength is presented. It is purely based on split-block hollow-metal waveguide technology. The synthesis process starting at the equivalent lowpass filter is demonstrated, involving the use of K-inverters and equivalent circuits for waveguide discontinuous. This results in a compact iris filter with less than 1.2 GHz bandwidth at 94 GHz and more than 40 dB suppression at 0.5 GHz offset while the insertion loss is kept as low as 3 dB. The design is verified by EM simulation and experimental characterisation of a manufactured prototype to underline the potential of the filter for innovative system design in the millimetre wave range.

PO1.12: Rapid Patch Antenna Array Design for a Satcom- Demonstrator

Korbinian Schraml, Ralf Wilke, Dirk Heberling
RWTH Aachen Universität, Germany

This paper presents an efficient, systematic approach to design a set of antenna demonstrators. The process and its building blocks are explained as well as a short overview on two examples of antenna arrays is given.

PO1.13: The Influence of Rain on Small Aperture LiDAR Sensors

Thomas Fersch[1,2], Alexander Buhmann[2], Alexander Kölpin[1], Robert Weigel[1]
[1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; [2]Robert Bosch GmbH Germany

The influence of rain on pulsed LiDAR systems with a miniaturized aperture and small laser beam cross sections was investigated based on two situations deemed critical. First, discrete rain drops appearing very close to the laser aperture could lead to a complete deflection of the laser beam out of the original direction when drop and beam overlap. Our semi-probabilistic, semi-analytical model however indicates that the rate of deflected scan events is negligible. Second, the emitter surface could be, to a greater or lesser extent, covered with drops of various size, degrading the performance. We found an optimum ratio between drop diameter and laser beam diameter, favoring larger laser beams. Also this effect however is, in total, not critical.

PO1.14: Linearity and Efficiency Improvement using Envelope Tracking Power Amplifier

Felix Auer, Stefan Schiller, Michael Kamper
Fraunhofer IIS, Germany

Linearity improvement of power amplifiers (PA) with envelope tracking (ET) modulators is presented. ET modulators vary the supply voltage of RF power amplifiers to optimize the efficiency. In this work techniques of shaping the ET waveform are shown and their linearizing features on a linear power amplifier analytically studied. An optimized ET amplifier system is presented employing improved efficiency and intermodulation distortion ratio (IMD) compared to the static case.

PO1.15: Farfield Coupling of Antennas in terms of S-Parameters

Andreas R. Diewald
Hochschule Trier, Germany

In a former publication the author reported some results about antenna coupling which are calculated by an analytical approach without going into detail. The derivation of this analytical approach is given in this paper. The scattering parameters of purely passive antennas including the phase information is calculated. The method is used for an in-house developed radar simulator for active and passive electromagnetic sensing.

Tuesday, 15 March 2016

Time	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 03/445	ID 04/459+471 ID 04/401
08:00–08:30	Registration			WS2: CST Industrial Workshop			
08:30–09:50		S04: Microwave Sensors	S05: Power Amplifier 1	WS2: CST Industrial Workshop	MTT/AP Chapter Meeting		Exhibition (from 09:10)
09:50–10:10	PO2	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Exhibition
10:10–11:50		S06: MIMO Radar and SAR	S07: Filter	WS3: Ansys Industrial Workshop		Design Competition	Exhibition
11:50–12:50	PO2: Interactive Poster Session	Lunch Break	Lunch Break	Lunch Break	IMA Meeting		Exhibition
12:50–14:00		Plenary Session, Keynotes (HID)	Plenary Session, Keynotes (HID)	Plenary Session, Keynotes (HID)	Plenary Session, Keynotes (HID)	Plenary Session, Keynotes (HID)	Exhibition
14:00–15:40		S08: Radar Signal Processing	S09: Steerable Antennas	WS4: IMST Industrial Workshop		Design Competition	Exhibition
15:40–16:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Exhibition
16:00–17:40		S10: Integrated Circuits	S11: Microwave Tubes	SP3: Special Session - Radar Systems			
17:40–18:15	Transfer by Coach to 'Henrichshütte'						
18:15–23:15	Evening Event / Conferernce Dinner						
23:15–23:45	Transfer by Coach to Bochum City Centre						

S04: Microwave Sensors

Chairs: Karam Noujeim (Anritsu, USA), Dirk Nüßler (Fraunhofer FHR, Germany)

Room: HID Time: 08:30 – 09:50

S04.1: Differential Measuring Dual Six-Port Concept and Antenna Design for an Inline Foil Thickness Sensor

Sebastian Mann[1], Sarah Linz[1], Stefan Erhardt[1], Stefan Lindner[1], Fabian Lurz[1], Holger Maune[2], Robert Weigel[1], Alexander Kölpin[1]

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; [2]Technische Universität Darmstadt, Germany

Time: 08:30 -08:50

Sensor elements play an important role in future manufacturing plants. This paper presents a solution for a foil thickness sensor for running production lines. Based on the elaborated Six-Port concept, a differential measuring concept is proposed and discussed. Furthermore, an end-fire antenna design for the addressed application is demonstrated and far field measurement results are shown and compared to simulation. Finally, interference effects between two antennas are experimentally investigated as a function of the relative rotation between two oppositely placed devices.

S04.2: A 868 MHz Wireless Transmitter for a Sensor-System-in-Foil

Jochen Briem, Markus Grözing, Manfred Berroth

Universität Stuttgart, Germany

Time: 08:50 -09:10

This paper presents a 868 MHz Wireless transmitter on an ultra-thin 0.5 µm CMOS gate-array for a wireless and bendable sensor-system-in-foil. Because of the technology constraints an ASK modulation is used. The simulated maximum output power is 10 dBm. As required for the application specific developed protocol, the transmitter's switch-on time is very low. Thus the presented PLL has an optimized lock-in time, without distorting spectrum or stability. Furthermore a flexible biasing network optimizes oscillator behavior and enables proper PLL-functionality at different process-corners.

S04.3: A 24 GHz Dielectric Sensor Based on Distributed Architecture

Farabi Jamal, Subhajit Guha, Mohamed Hussein Eissa, Dietmar Kissinger, Jan Wessel
IHP, Germany
Time: 09:10 -09:30

In this paper, a dielectric sensor based on distributed architecture topology is presented. The measured sensor delivers the dielectric information as a notch frequency between 21 GHz to 25 GHz. The proposed sensor is intended to perform as a microwave dielectric sensor to identify bio-materials but can be used for other applications as well. It is fabricated in a standard 0.25 µm SiGe BiCMOS process with HBTs (fT /fmax = 120/140 GHz) and it consumes 13.4 mW DC power. The sensor has been simulated and measured with different dielectric materials. For proof of concept, first experiments have been conducted for air, epoxy resin and honey. Owing to the distributed concept and the destructive interference, a sensitivity of 0.32 GHz per unit permittivity (1.35% of the center frequency) was achieved. Based on these permittivity measurements, the presented results illustrate that this technique is a promising solution for biomaterial sensing and characterization.

S04.4: Design and Realization of a Microwave Applicator for Diagnosis and Thermal Ablation Treatment of Cancerous Tissue

Carolin Reimann, Margarita Puentes, Martin Schüßler, Rolf Jakoby
Technische Universität Darmstadt, Germany
Time: 09:30 -09:50

Microwave sensors play a significant role in medical environments. The contact-less and non-invasive sensing mechanism to determine the dielectric properties of tissue is of great advantage. In this work, a dual mode microwave sensor is designed to combine the diagnosis and treatment of cancer in one minimal invasive surgery tool. In order to detect abnormalities, the relative change of permittivity of healthy tissue compared to tumor tissue is evaluated. For the treatment mode, microwave ablation is used to eradicate malignant cells. The challenges of the design process are the dimension limitation and packaging with an appropriate interface of the sensor integrated in a needle-like surgery tool. The small size leads to a significant increase of the operating frequency up to 40 GHz with the advantage of using very low input power for the thermal ablation procedure. The sensor provides a maximum temperature of over 100°C with 2 W input power. Prototypes of the proposed sensors are fabricated to measure the transmission characteristics of the structures unloaded and loaded.

S05: Power Amplifier 1

Chairs: Manfred Berroth (Universität Stuttgart, Germany),
Georg Fischer (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)
Room: HIC Time: 08:30 – 09:50

S05.1: Load Modulation with an Adaptive Matching Network Based on MEMS for Efficiency Enhancement of an Inverse Class-F Power Amplifier

Steffen Probst, Bernard Lüers, Bernd Geck
Leibniz Universität Hannover, Germany
Time: 08:30 -08:50

In this contribution a 10 Watt gallium nitride (GaN) based inverse class-F power amplifier with an adaptive matching network realized with MEMS (micro electro mechanical systems) is presented. The developed power amplifier uses an adaptive output matching network for the enhancement of the power added efficiency over the dynamic output range. With the output matching network an efficiency enhancement of 20% at 10-dB-back-off is achieved.

S05.2: A 56 W Power Amplifier with 2-Level Supply and Load Modulation

Sebastian Kelz[1], Martin Schmidt[2], Nikolai Wolff[1], Manfred Berroth[2], Wolfgang Heinrich[1], Olof Bengtsson[1]
[1]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany;
[2]Universität Stuttgart, Germany
Time: 08:50 -09:10

Dynamic load modulation is proposed to improve the efficiency of an RF power amplifier with discrete supply modulation. A 47.5 dBm, 2.7 GHz power amplifier is realized to show the potential of the method. The amplifier design is based on continuous wave load-pull measurements to determine the optimum load impedances, using the statistics of a 10.2 dB PAPR OFDM signal. The output network contains a single SiC varactor for adaptive output matching. The supply voltage is adjusted by a 2-level supply modulator. Static evaluation of the amplifier shows an improvement in PAE of approximately 9.7 percentage points at 10 dB back-off due to load modulation.

S05.3: Challenges in the Design of Wideband GaN-HEMT based Class-G RF-Power Amplifiers

Nikolai Wolff, Wolfgang Heinrich, Olof Bengtsson
Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany
Time: 09:10 -09:30

In GaN-based power amplifiers (PA) the gain under continuous wave (CW) excitation compresses slowly over a wide power range. Also, due to memory-effects in the GaN-HEMT, the gain for modulated excitation with varying envelope differs from the CW value. On the other hand, design approaches for supply voltage modulated systems based on post-processing of CW measurements are in widespread use. This paper scrutinizes these approaches in a case study for a class-G modulated PA, i.e. A PA with discrete supply modulation. The errors related to the CW design approach are quantified by comparison with dynamic measurements. Test-signals with equal power distributions but varying modulation bandwidths in a range of 4 MHz to 32 MHz are used. It is found that the dynamic measurement results deviate from the expected CW performance by up to 5% in PAE and 1.5 dB in gain. Responsible for this are on one hand differences in CW and modulated gain. On the other hand the efficiency degrades with increasing supply voltage switching frequency, which is related to the modulation bandwidth and the supply voltage levels.

S05.4: A Flexible, Dynamically Load-Modulated GaN Power Amplifier for the UHF band

Konstantinos Mimis, Gavin Watkins
Toshiba Research Europe Ltd., United Kingdom
Time: 09:30 -09:50

A GaN power amplifier is presented with a tunable output matching network, based on varactor diodes which provide a dual functionality. Firstly, they enhance back-off efficiency through dynamic load-modulation (between 0.9-1.0GHz). Secondly, they re-configure the amplifier to operate over additional frequencies (between 0.6-0.9GHz). The prototype PA measured with a 1.4MHz LTE signal, and after optimisation of the drain supply level, delivered 33.7-35.1dBm with 33.2-47.9% efficiency over 0.6-1.08GHz and <-28.2dBc ACPR, without any linearisation. Finally, output power control is demonstrated through simple supply voltage scaling with high efficiency maintained over a 10 dB output power dynamic range.

S06: MIMO Radar and SAR

Chairs: Lorenz-Peter Schmidt (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany), Thomas Zwick (Karlsruhe Institute of Technology, Germany)

Room: HID Time: 10:10 – 11:50

S06.1: MIRANDA 35 GHz SAR Based Change Detection

Denis Noetel, Frank Kloeppel, Stefan Sieger, Daniel Janssen, Nils Pohl
Fraunhofer FHR, Germany

Time: 10:10 -10:30

The presented MIRANDA 35 SAR sensor together with an ultralight aircraft allows for ever higher revisit counts of test scenes. Seven sets of test data have been acquired over a change detection scene, allowing for statistics-based change detection algorithms to be tested. Informational Difference and Universal Image Quality Index lend themselves to change detection based on intensity images. We show here that both methods can result in successful change detection.

S06.2: A System Concept for a 3D Real-Time OFDM MIMO Radar for Flying Platforms

Alexander Ganis[1], Enric Miralles Navarro[1], Christoph Heller[2], Ulrich Prechtel[1], Volker Ziegler[1], Askold Meusling[3], Heinz-Peter Feldle[3], Mirko Loghi[4], Frank Ellinger[5]
[1]AIRBUS Group Innovations, Germany; [2]EADS Innovation Works, Germany; [3]AIRBUS Defence & Space, Germany; [4]University of Udine, Italy; [5]Technische Universität Dresden, Germany

Time: 10:30 -10:50

In this paper a new system concept for a low cost, miniaturized and real-time imaging radar system for flying platforms is presented. The proposed solution is based on the MIMO radar architecture, orthogonal signals for simultaneous transmit capabilities and highly integrated SiGe chipsets. Using beamforming techniques at the receiver together with radar processing techniques, a 3D sensing of the range, azimuth, elevation and Doppler information for an arbitrary number of objects can be estimated through a simultaneous transmission and with real-time hardware implementable FFT processing techniques. A top-level system concept and a complete parametrization is proposed for a radar system which is intended for obstacle warning for helicopters and to enhance flight safety in approach, landing and take-off phases of flight even in degraded visual conditions. The full OFDM MIMO Radar system has been implemented and tested in a MATLAB environment and simulation results are here presented. This paper is the first step towards the implementation of a compact and real-time radar system demonstrator.

S06.3: Ultra-High Resolution SAR in Lower Terahertz Domain for Applications in Mobile Mapping

Stephan Palm[1], Rainer Sommer[1], Michael Caris[1], Nils Pohl[1], Axel Tessmann[2], Uwe Stilla[3]
[1]Fraunhofer FHR, Germany; [2]Fraunhofer IAF, Germany; [3]Technische Universität München, Germany
Time: 10:50 -11:10

Mobile Mapping is currently dominated by optical camera or laser based systems. Due to new semiconductor technologies, compact and light weight FMCW radar systems in the lower terahertz domain become applicable for such scenarios. With constant increasingly higher resolution capabilities in the subcentimeter domain such radar sensors could supplement existing sensor suites in challenging environments. Their electromagnetic waves exhibit only low absorption due to smoke, fog and dust and are independent from sunlight. Data were collected with the Miranda 300 GHz radar system in SAR mode with 30 GHz bandwidth mounted on a platform in a conventional van. Preliminary results from terahertz SAR data were processed using a time domain approach finally reaching a 5 mm resolution. The SAR system's ability of resolving very small metallic objects placed in the scenario was validated. Details in the SAR images are disclosed in unprecedented quality in terms of radar imaging. Objects down to a radar cross section of -43 dBsm could be resolved.

S06.4: 3D Radar Image Fusion using OFDM-based MIMO Radar

Benjamin Nuss, Leen Sit, Thomas Zwick
Karlsruhe Institute of Technology, Germany
Time: 11:10 -11:30

This paper presents two data fusion algorithms for use in an OFDM-based MIMO radar network, comprising several radar nodes for area surveillance applications. Each node is able to estimate four parameters - 3D positions (range, azimuth and elevation) as well as the velocity of an arbitrary number of targets within one transmit cycle. The raw radar images are then stitched together for higher target estimation accuracy as well as to reveal targets that are hidden from certain nodes due to obstacle shadowing. The first algorithm estimates the 3D target position within the area of observation. The second estimates the 2D (azimuth and range) as well as the velocity parameters. The performance of the algorithms and the radar system is evaluated with numerical simulations.

S06.5: Coherent Resampling for Coherent MIMO Radar Setups

Andreas Kirschner
Technische Universität München, Germany
Time: 11:30 -11:50

In the recent decade, coherent MIMO radar systems have been examined intensively. Usually out of focus is the signal modulation. Of course, the same modulation schemes for any other radar type find re-use here. With respect to system implementation, also modulation usually underlies errors such as non-linearities, phase noise etc. Nevertheless, the academic world in turn has developed methods for calibration, correction and error prediction for radar signal modulation, too. One of these methods is the so-called resampling method which had been developed for correction of linear frequency modulations. However, the convolution operation in coherent MIMO radars with collocated antennas brings in another grade of complexity. This paper sketches the efforts needed for the resampling method in case of coherent MIMO radars.

S07: Filter

Chairs: Amelie Hagelauer (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany), Jan Hesselbarth (Universität Stuttgart, Germany)

Room: HIC Time: 10:10 – 11:50

S07.1: A New Compact Microstrip Slow Wave Open Loop Resonator Filter with Improved Spurious-Free Band

Payman Rezaee, Michael Höft
Universität Kiel, Germany
Time: 10:10 -10:30

In this paper, a new microstrip slow wave open loop resonator is proposed. This resonator improves the spurious-free band up to 5.1 times of the fundamental frequency which is more than 2 times of the conventional slow wave open loop resonators. Based on the proposed resonator, two three-pole filters are designed and one of them is fabricated. Simulation and measurement results are reported which are in good agreement. Designed filters provide 75% and 83% of footprint reduction in comparison with the conventional open loop resonator filters.

S07.2: Barium Hexaferrite Films Prepared by Means of the Sol-Gel Method for Self-Biased Nonreciprocal Microwave Devices

Frauke Gellersen, Felix Klichowski, Adrian Rusche, Arne Jacob
Technische Universität Hamburg-Harburg, Germany
Time: 10:30 -10:50

In this work barium hexaferrite films for self-biased nonreciprocal devices are produced by means of the sol-gel method. The effect of the drying temperature on the film surface is examined via scanning electron microscopy. The influence of the crystallization temperature and the composition of the precursors on secondary phases is analyzed via X-ray diffraction analysis. Measurements of a coplanar waveguide with a barium hexaferrite thin film show nonreciprocal behavior at the ferromagnetic resonant frequency in the Q-band without external biasing field.

S07.3: Design and Comparison of Various Coupled Line Tx-Filters for a Ku-Band Block Upconverter

Daniel Maassen, Felix Rautschke, Georg Boeck
Technische Universität Berlin, Germany
Time: 10:50 -11:10

In this contribution common coupled line filter topologies are developed for their application as Tx-filter in a Ku-band block upconverter (BUC) from 13.75 - 14.5 GHz. Tough requirements of Rx-, LO- and second harmonic suppression were achieved by a detailed analysis of the metallic losses as well as equalizing even- and odd-mode velocities of the coupled line section. Four different filters were designed on an alumina substrate resulting in high measured performance values and small size compared to other work. By using a hairpin topology a designed filter achieves a low insertion loss (IL) less than 1.5 dB, a return loss (RL) of better than 20 dB, for a 3 dB fractional bandwidth (FBW) of 14.7 % while maintaining a second harmonic suppression of more than 20 dB.

S07.4: Tunable Lumped-Element-Filter for RF Power Applications Based on Printed Ferroelectrics

Alex Wiens[1], Christian Schuster[1], Christian Kohler[2], Martin Schüßler[1], Joachim Binder[2], Rolf Jakoby[1]
[1]Technische Universität Darmstadt, Germany; [2]Karlsruhe Institute of Technology, Germany
Time: 11:10 -11:30

This work addresses center frequency and band-width tunable filter for implementation in RF base-station front-ends. The filter is fabricated using functional thick film layers of Barium-Strontium-Titanate (BST). The deposition of BST layers is performed locally in a screen printing process. The fabricated varactors have a Q-factor around 40 at 1 GHz, a tunability larger than 50% and a measured IP3 higher than 65 dBm. The filter is designed to cover typical GSM frequencies from 700 MHz to 960 MHz and 60 MHz to 100 MHz bandwidth. The simulated insertion loss is around 2.2 dB and 3.0 dB, depending on the center frequency and bandwidth. Measurements of the filter reveal an insertion loss of 6 dB to 9 dB which is at least 4 dB higher than predicted by simulations. Analysis showed that the high insertion loss is caused by shifted poles as a consequence of the fabrication tolerances of the varactors.

S07.5: A 60MHz OTA-based IF Filter for Wireless Wake-Up Receivers with 115ns Settling Time

Christoph Tzschoppe, Alexander Richter, Markus Schulz, Corrado Carta, Frank Ellinger
Technische Universität Dresden, Germany
Time: 11:30 -11:50

This paper presents the design and characterization of a fully-differential intermediate frequency (IF) filter based on an operational transconductance amplifier (OTA) with 6th order Butterworth bandpass characteristic. The designed 2-stage BiCMOS OTA can be treated as an operational amplifier (OPAmp) together with its output resistance: the combination exhibits an open-loop voltage gain of 75dB and high gain-bandwidth product (GBP) of 5.8GHz, while stability is achieved with a worst case phase margin (PM) of 54◦ from a low bias-current of only 520µA. The multiple-feedback filter (MFB) elements for the target Butterworth frequency response are determined with circuit analysis based on an ideal OTA transfer function. The filter center frequency is set to 60MHz, whereby a measured -3dB-bandwidth of 16MHz is achieved. To enable the operation within an on-time of 200ns the filter is able to settle at ±1dB of its steady state amplitude in less than 115ns. The filter was fabricated in the IHP 130nm BiCMOS technology and requires a current of only 1.6mA from a 2.5V-supply including all bias circuits.

S08: Radar Signal Processing

Chairs: Joachim Ender (Fraunhofer FHR & Universität Siegen, Germany),
Mario Pauli (Karlsruhe Institute of Technology, Germany)
Room: HID Time: 14:00 – 15:40

S08.1: Detection of Fluid Vortices based on Compensated FMCW-Radar Phase Measurements

Birk Hattenhorst, Christoph Baer, Thomas Musch
Ruhr-Universität Bochum, Germany
Time: 14:00 -14:20

In this contribution, a measurement concept for the detection of fluid vortices is presented. The approach utilizes the pressure-dependent relative permittivity of gases, which connected to the pressure distribution of a gas vortex leads to a detectable permittivity deviation. Since the measurement effect is very small, phase measurements of a high precise and low jitter FMCW-radar system are applied. Moreover, disturbances caused by vibrations of the measurement setup are compensated out of the measurement signal.

S08.2: A Super-Resolution Polarimetric Direct Mapping Imaging Algorithm for a Bistatic SIMO UWB-Radar

Dilyan Damyanov[1], Rahmi Salman[2], Thorsten Schultze[1], Ingolf Willms[1]
[1]Universität Duisburg-Essen, Germany; [2]HF Systems Engineering GmbH & Co. KG & Hübner Holding GmbH, Germany
Time: 14:20 -14:40

In this paper a real time capable 2D imaging method for ultra-wideband Radar is presented. A well known wavefront localization method based is adapted and improved using a super-resolution wavefront extraction method and exploring the polarimetric information of the target under test. The imaging algorithm is real time capable and directly maps an extracted wavefront to the target contour in contrast to classical popular migration algorithms. Furthermore, the new proposed imaging algorithm is designed for a circular scanning trajectory, or a rotating target and a bi-static antenna configuration with two receiver antennas. Experimental validations are performed with a geometrically complex object, a M-sequence UWB Radar device (4.5 GHz - 13.5 GHz) and compact Vivaldi Ultra-Wideband antennas.

S08.3: Multi-Spectral Echo Signal Processing for Improved Detection and Classification of Radar Targets

Michael Vogt, Thorsten Neumann, Michael Gerding, Christoph Dahl, Ilona Rolfes
Ruhr-Universität Bochum, Germany

Time: 14:40 -15:00

A major challenge in radar based remote sensing and imaging is to identify and to detect radar targets, and also to accurately determine their locations and sizes. This especially applies in the case of multiple, spatially distributed radar targets, for example in radar imaging, radar level measurement of bulk solids in silos, automotive radars, and others. In this paper, a concept for multi-spectral analysis and processing of echo signals is presented and discussed, which has been investigated for scanning radar applications. The proposed technique is based on filtering the radar echo signals in multiple frequency sub-bands and incoherently combining the filtered signals. Furthermore, the variance of envelope signals is analyzed in order to allow for a differentiation between echoes from distributed, randomly arranged scatterers and from spatially isolated single scatterers. The mean over the standard deviation of the envelope signals obtained from the different sub-bands is suggested to be used as an amplitude-invariant parameter for the classification of radar targets. Results of an experimental evaluation of the concept using a mechanically scanning 75 to 80 GHz Frequency Modulated Continuous Wave (FMCW) radar system are presented. It will be shown that the proposed technique enables to largely suppress the echo signal fluctuations, which are given in scenarios of spatially distributed radar targets, and also to distinguish between different kinds of radar targets.

S08.4: Radar Array Self-Calibration and Imaging with Applications to Bulk Material Gauging

Dominik Zankl[1], Stefan Schuster[2], Reinhard Feger[1], Andreas Stelzer[1]
[1]Johannes Kepler Universität Linz, Austria; [2]Voestalpine GmbH & Institute for Communications and Information Engineering, Austria

Time: 15:00 -15:20

Common algorithms for radar array imaging rely on sufficiently precise calibration before evaluation. A system calibration is necessary to compensate potential unavoidable error sources that decrease the accuracy and reliability of the estimates and worsen the beam pattern of the antenna array. Several calibration methods have been developed, most of them are based on a-priori, i.e., offline measurements with a well defined target scenario. In this paper we present an algorithm that is capable of

executing an online self-calibration and image formation for the special case when the target scenario is an arbitrary but continuous surface. The two separated tasks, system calibration followed by image formation, are combined in a single formulation that efficiently solves a minimization problem. Thus, the need for a-priori calibration measurements is avoided. The correct functionality of this algorithm is shown with simulation results for different surface scenarios and spatial dimensions. A possible real-world application in blast furnace burden surface imaging is discussed.

S08.5: Range Migration Compensation for Chirp-Sequence based Radar

Fabian Roos[1], Daniel Ellenrieder[1], Nils Appenrodt[2], Juergen Dickmann[2], Christian Waldschmidt[1]
[1]Universität Ulm, Germany; [2]Daimler AG, Germany

Time: 15:20 -15:40

To improve the range and Doppler resolution the bandwidth and the observation time need to be increased. This leads to a range migration effect and thus to a declining separability of targets. This paper compares three different modulation formats to cope with the range migration. The standard chirp-sequence modulation, the bandwidth variation modulation known from literature and the proposed chirp duration variation. A simulation is used to validate the modulation format.

S09: Steerable Antennas

Chairs: Matthias Hein (Technische Universität Ilmenau, Germany),
Peter Knott (Fraunhofer FHR, Germany)
Room: HIC Time: 14:00 – 15:40

S09.1: An Electronically Reconfigurable Reflectarray Based on Binary Phase Shifters for K-Band Radar Applications

Helen Theissen, Christoph Dahl, Thomas Musch, Ilona Rolfes
Ruhr-Universität Bochum, Germany

Time: 14:00 -14:20

This contribution presents a reflectarray antenna at 24 GHz allowing electronic beam-scanning. The antenna elements are comprised of aperture-coupled patch antennas with openended microstrip lines on the backside to obtain the proper phase distribution on the reflectarray aperture. Electronic beamsteering is achieved by applying PIN diodes on the individual reflectarray elements. To simplify the control process of the antenna, the elements function as one-bit phase shifters either reflecting with 0° or 180° phase shift.

S09.2: A Frequency Steerable Substrate-Integrated Waveguide Slot Antenna for 77 GHz Radar Application

Tim Martin Böbel[1], Thomas Dallmann[1], Matthias Rabel[2], Dirk Heberling[1]
[1]RWTH Aachen Universität, Germany; [2]Indurad GmbH, Germany

Time: 14:20 -14:40

For a low cost radar system a serially fed, linear and equidistant waveguide slot antenna has been developed. A meander shaped waveguide path allows a frequency steerable main lobe without additional mechanical or electrical components. The antenna design focused on a maximum steering angle of ±60°. In order to further reduce the costs and simplify fabrication of the antenna a Substrate-Integrated Waveguide (SIW) structure was used. A new concept to reduce the parasitic coupling of these structures has been investigated. To fulfill the requirements on the radiation characteristics and matching of the antenna, a new slot shape and a cavity based waveguide-SIW transition were designed. Simulations and measurement results show that the antenna could be realized successfully.

S09.3: Steerable Ka-Band Dual Reflector Antenna

Tatjana Gabriel[1], Horst Kozilek[1], Christian Hartwanger[2], Marko Gerhard[1], Michael Schneider[1]
[1]Airbus DS GmbH, Germany; [2]EADS Astrium GmbH, Germany

Time: 14:40 -15:00

Airbus DS GmbH has been developed a Ka-band antenna assembly which offers steerable up- / downlink connections (rx, tx) for satellites in LEO. The antenna consists of a dual reflector antenna and a mechanical steering mechanism. The pointing mechanism comprises the steering unit, a standardised azimuth stage and an elevation stage which is custom-made. The Ka-band antenna assembly (KAA) is part of the Antenna Pointing Assembly (APA) product family by Airbus DS GmbH. The steerable antenna system KAA was completely developed in Germany and is not subject to ITAR. The antenna has to fulfill strict requirements concerning gain, sidelobes and polarisation purity and the agile steering mechanism needs a highly stable and symmetric structure of the antenna. Therefore the antenna is designed as a centre-fed dual reflector antenna. The engineering model is ready for qualification. The antenna was optimised by means of a hybrid approach and different calculation techniques.

S09.4: Modular Steerable Active Phased Array Antenna at 2.4 GHz

Niels Neumann[1], Christoph Hammerschmidt[2], Martin Laabs[1], Dirk Plettemeier[1]
[1]Technische Universität Dresden, Germany; [2]BIOTRONIK GmbH SE & Co. KG, Germany

Time: 15:00 -15:20

Phased array antennas can cover a wide range of applications, e.g. localizing passive tags. Depending on the specifications for antenna gain, beam width and scanning range, different antenna elements and number of antennas are required. This kind of flexibility is provided by a modular approach consisting of a control unit and backplanes that carry RF and antenna modules where amplitude and phase shifting needed for beamforming takes place. Furthermore, an initial calibration of the antenna has to be carried out in order to compensate for tolerances in the manufacturing process. In this paper, a 4x4 array is realized and presented which allows full 2D beamsteering. Comprehensive measurement results are shown and discussed.

S09.5: 200 GHz 1×4 Antenna Array Based on Planar Butler Matrix

Michael Jenning, Dirk Plettemeier
Technische Universität Dresden, Germany

Time: 15:20 -15:40

We present a fully planar Butler Matrix (BM) design for 180 GHz operational frequency and a bandwidth of better than 30 GHz. The most important component in such a design is the planar crossover, which is investigated and optimized. Furthermore, two antenna elements are investigated and optimized to work in conjunction with the BM to form the antenna array. Simulations reveal that one of the arrays is able to provide better than 10 dB gain for all frequencies and beams.

S10: Integrated Circuits

Chairs: Dietmar Kissinger (IHP, Germany), Hermann Schumacher (Universität Ulm, Germany)

Room: HID Time: 16:00 – 17:40

S10.1: 10 to 40 GHz Superheterodyne Receiver Frontend in 0.13 µm SiGe BiCMOS Technology

Hebat-Allah Abdeen[1], Shuai Yuan[1], Hermann Schumacher[1], Volker Ziegler[2], Askold Meusling[2], Heinz-Peter Feldle[2]

[1]Universität Ulm, Germany; [2]Airbus Defence & Space, Germany

Time: 16:00 -16:20

A fully integrated 10-40 GHz superheterodyne receiver frontend using a 40-46 GHz IF is presented. The frontend consists of a differential low noise amplifier, a fully differential mixer, a single-ended frequency quadrupler and a transformerbased balun followed by an amplifier to convert the quadrupler's single-ended output to a differential signal to drive the LO port of the mixer. The circuit is designed and fabricated in a 250 GHz fT SiGe BiCMOS technology. The chip was characterized on-wafer single-endedly. The frontend achieves a differential conversion gain of 17 to 20 dB and an input-referred 1 dB compression point of -16 to -20 dBm across the desired IF bandwidth.

S10.2: An OOK-Modulator at 240 GHz with 20 GHz Bandwidth

Pedro Rodriguez-Vazquez[1], Neelanjan Sarmah[1], Klaus Aufinger[2], Ullrich Pfeiffer[1]

[1]Universität Wuppertal, Germany; [2]Infineon Technologies AG, Germany

Time: 16:20 -16:40

In this paper, we present an OOK-modulator with a LO at 240 GHz for incoherent high data rate communication systems. The modulator topology is similar to a selector where one of the data input is connected to the ground and the baseband signal is fed to the clock input. This circuit is implemented in 130 nm SiGe HBT technology with fT /fmax of 250/370 GHz. The measured 3 dB RF bandwidth is 20 GHz and the estimated data rate with OOK modulation scheme is 13.3 Gbps. The dc power consumption for the modulator is 30 mW.

S10.3: Low power High-speed 10 Gb/s 4:1 Multiplexer for Sliding-IF digital Centric Transmitter in 65nm CMOS

Pierre Bousseaud, Renato Negra

RWTH Aachen Universität, Germany

Time: 16:40 -17:00

This paper presents a high speed 4:1 multiplexer (MUX) which can operate up to 10 Gb/s. The circuit adopts a simple transmission gate (TG) structure for low power consumption and saving area as well. It is dedicated to be employed into a sliding-IF transmitter architecture and acts as a digital multiplier in order to convert I/Q baseband data into a digital serial data stream before being up-converted into the analog domain through a radio-frequency digital-to-analog-converter (RF-DAC). In order to avoid glitches due to clock desynchronization, a 4-bit selectable delay-cell array is used for proper alignment configuration. The simulation results after post-layout extraction show a power consumption less than 5 mW under a 1.2 V supply voltage. The circuit has been designed in 65nm TSMC CMOS technology.

S10.4: Hybrid-Integrated RF MEMS-based Reference Oscillator Using a Silicon-Ceramic Composite Substrate

Johannes Stegner, Uwe Stehr, Dmitry Podoskin, Sebastian Gropp, Michael Fischer, Martin Hoffmann, Jens Müller and Matthias Hein
Technische Universität Ilmenau, Germany
Time: 17:00 -17:20

In this paper, the design of a RF MEMS oscillator on a silicon-ceramic composite substrate using a high-Q Lamb-wave resonator as frequency-selective device is described. The MEMS resonator is designed on a 1.8 um thick piezoelectric AlN layer, deposited on silicon using thin-film processes. The finite-element simulation results of the resonator structure are presented, and the derivation of the electrical equivalent-circuit is described. The active part of the MEMS oscillator, which was laid out in a Pierce topology, has been integrated in an application-specific integrated circuit fabricated in CMOS technology. Both, amplifying and frequency-selective parts are hybrid-integrated on an innovative silicon-ceramic composite substrate, which enables a very compact high-quality module design with minimal parasitics. The MEMS oscillator serves as a technology demonstrator combining the advantages of microelectronic and micro-electromechanical components towards a compact and power-efficient hybrid technology, e.g. for mobile communications or wireless sensors.

S10.5: Integrated Tri-State PLL for the Control of a Switched Injection-Locked Oscillator at 2.45GHz

Markus Schulz, Niko Joram, Mohammed El-Shennawy, Christoph Tzschoppe, Frank Ellinger

Technische Universität Dresden, Germany

Time: 17:20 -17:40

This paper presents a novel combination of two fully integrated phase-locked loops (PLLs) to control the oscillation frequency and modulation frequency of a switched injection- locked oscillator (SILO). The SILO is used as an active reflector transponder in a frequency-modulated continuous wave (FMCW) radar system. A fractional-N PLL (RF-PLL) with a tri-state phase-frequency detector (TSPFD) sets the oscillation frequency of the voltage controlled oscillator (VCO) to 2.45GHz. Another integer-N PLL (modulation PLL) switches the tail current source of the VCO to achieve SILO behavior at the time when the RF-PLL is not controlling the VCO. The RF-PLL supports division ratios from 64 to 511 with a frequency resolution of 0.2Hz. Reference spur levels are below -48dBc while the out- of-band phase noise is -103dBc/Hz at a 1MHz frequency offset. The modulation PLL is based on a Maneatis-cell ring-oscillator supporting modulation frequencies between 6MHz and 20MHz. Furthermore, the duty cycle of the modulation signal can be set in steps of 0.8%. Due to the novel TSPFD, the oscillation frequency of the SILO changes only by 36MHz within 10 minutes when the RF-PLL is inactive. The complete circuit is manufactured in a 180nm SiGe BiCMOS process and consumes a total power of 128mW.

S11: Microwave Tubes

Chairs: Dirk Plettemeier (Technische Universität Dresden, Germany),
Werner Wiesbeck (Karlsruhe Institute of Technology, Germany)
Room: HIC Time: 16:00 – 17:40

S11.1: Design Procedure for Hot-Matched Severs in Folded-Waveguide Traveling-Wave Tubes

Sascha Meyne, Djamschid Safi, Arne Jacob
Technische Universität Hamburg-Harburg, Germany
Time: 16:00 -16:20

A design procedure for a hot-matched sever for folded-waveguide traveling-wave tubes (FW-TWTs) is proposed. To determine a starting point for a suitable load design, a realistic, three-dimensional sever structure is developed using equivalent circuits and subsequent particle-free (cold) full-wave simulation. Additional wave impedance information, obtained by a small-signal eigenvalue analysis, is used to improve the termination for hot operation. The final full-wave optimization is then performed in the presence of the electron beam with only moderate computational effort. This procedure is applied to develop a sever structure for a given frequency point at Q-band. The simulated results validate the approach.

S11.2: Preliminary Studies on Multistage Depressed Collectors for Fusion Gyrotrons

Chuanren Wu, Ioannis Pagonakis, Stefan Illy, Manfred Thumm, Gerd Gantenbein, John Jelonnek
Karlsruhe Institute of Technology, Germany
Time: 16:20 -16:40

Fusion gyrotrons are microwave sources with MW power in the frequency range 100-300 GHz. An optimized energy exchange (interaction) between electron-beam and microwave has approximately 35% efficiency. Using a single-stage depressed collector (SDC), the overall efficiency of gyrotrons nowadays is around 50%, which means that power at the MW-level will be wasted. For higher efficiency, Multistage Depressed Collectors (MDC) could be employed. The principle of MDCs is to sort electrons by their energy and guide them to electrodes on proper voltages. However, MDCs for high frequency gyrotrons are nontrivial, because of their small-orbit hollow electron beams and the existence of a relatively strong magnetic field, which dominantly constrains and guides the electron beam. According to Busch's theorem, if both electric and this magnetic field are symmetric, the cyclotron motions of electrons are not able to be spatially separated; indeed, we propose a new approach for MDC, based on a spatial trajectory modulation caused by non-adiabatic transition in the symmetric fields. A two-stage collector is simulated using this modulation concept. The theoretically maximum possible collection efficiency for two-stages with this spent-beam is 77%, whereas 73% (i.e., 60% overall efficiency) is achieved in the simulation. Besides, the MDC has the advantage that the collector wall loading is sufficiently low, that electron beam sweeping is not necessary.

S11.3: Experimental Results and Outlook of the 2 MW 170 GHz Coaxial-Cavity Gyrotron towards Long Pulse Operation

Sebastian Ruess, Tomasz Rzesnicki, Ioannis Pagonakis, Thorsten Kobarg, Maximilian Fuchs, Gerd Gantenbein, Stefan Illy, Manfred Thumm, John Jelonnek
Karlsruhe Institute of Technology, Germany
Time: 16:40 -17:00

The development of the modular short-pulse pre-prototype as base for a 2 MW, 170 GHz, CW coaxial-cavity gyrotron as upgrade for the international fusion project ITER and beyond is in progress at Karlsruhe Institute of Technology (KIT). The current modular pre-prototype configuration allows the generation of > 2 MW RF output power in short-pulses with a reasonable electronic efficiency of approximately 30 % without depressed collector operation. Recently, experiments with a new Glidcop resonator have been performed. In single-stage depressed operation the overall efficiency of the gyrotron has been increased to ~48 %. In addition, an advanced water cooling system for a long pulse 2 MW gyrotron was developed. In this paper the experimental results, the suppression of the beam-halo and future plans for the 2 MW gyrotron will be presented.

S11.4: Nose-Cone Loaded Folded-Waveguide Delay Lines for Q-Band Traveling-Wave Tubes

Sascha Meyne[1], Philip Birtel[2], Arne Jacob[1]
[1]Technische Universität Hamburg-Harburg, Germany; [2]Thales Electronic Systems, Ulm, Germany
Time: 17:00 -17:20

A modified folded-waveguide (FW) delay line for traveling-wave tubes (TWTs) is proposed. The amplifier performance is assessed by full-wave and interaction simulation. Properly designed nose cones are shown to enhance the beam-wave coupling. This, in turn, improves the amplifier gain, a weak point of conventional FW-

TWTs. Also the achievable beam efficiency is increased without sacrificing too much bandwidth.

S11.5: A Fast Frequency Step-tunable 236 GHz Gyrotron Design for DEMO

Parth Chandulal Kalaria, Konstantinos Avramidis, Joachim Franck, Gerd Gantenbein, Stefan Illy, Ioannis Pagonakis, Manfred Thumm, John Jelonnek
Karlsruhe Institute of Technology, Germany
Time: 17:20 -17:40

As part of EUROfusion WP HCD EC project, the conceptual design of a 1 MW, 236 GHz hollow cavity gyrotron is ongoing at IHM, KIT for a DEMOnstration Power Plant (DEMO), along with the 2 MW coaxial cavity design concept. Fast-frequency tunable gyrotrons (tuning within a few seconds) are recommended for plasma stabilization using a fixed, nonmovable antenna. Here, the mode selection approach for such a frequency tunable gyrotron is presented and suitable operating modes for fast-frequency tunability is suggested. Magnetic field tuning has been confirmed as an effective technique to tune the gyrotron operating frequency. The step tunability of the 236 GHz gyrotron within the frequency range of ±10 GHz is theoretically demonstrated in steps of 2-3 GHz.

SP3: Special Session - Radar Systems

Chairs: Madhukar Chandra (Technische Universität Chemnitz, Germany),
Dirk Fischer (Münster University of Applied Sciences, Germany)
Room: ID 04/445 Time: 16:00 – 17:20

SP3.1: On the verification of the quantitative precipitation estimation based on quality assured polarimetric weather radar measurements at DWD

Patrick Tracksdorf
DWD, Germany
Time: 16:00 -16:20

For some time past weather radar measurements with high temporal- and spatial resolution represent the basic element for severe weather nowcasting, short term forecasting and warning management processes within the weather services. Thereby, the radar based quantitative precipitation estimation (QPE) is a very essential and useful input to the meteorologists, hydrologists and modellers. Having replaced almost all weather radar systems with modern polarimetric Doppler C-Band weather radar systems the Deutscher Wetterdienst (DWD) may now make use of the improved radar system sensitivity and, above all, the newly available polarimetric weather radar measurements. This contribution will describe the developments which aim to improve the operational procedure for the QPE at DWD. Especially, the realisation of the QPE procedure, which incorporates the utilisation of a preceding quality assurance of the radar measurements and a hydrometeor classification, will be presented. The verification procedure, which is necessary and crucial when attempting to use the developments in an operational environment, will be addressed in detail. A short outlook concerning necessary further developments closes this contribution.

SP3.2: Implementation and verification of hydrometeor classification for German weather radar network

Jörg Steinert, Patrick Tracksdorf
DWD, Germany
Time: 16:20 -16:40

The German national weather service DWD maintains a C-band radar network including 17 weather radar systems operated on a 24/7 base and one system for research. Beside the replacement of the hardware to get dual polarisation capability, an algorithm for the estimation of the hydrometeor class was established among others. Notwithstanding, the advanced radar measurements like ZDR, KDP and RHOhv deliver further characteristics of the ensemble of hydrometeors, additional input of the temperature is suggested to improve the hydrometeor classification. For this purpose, the results of the numerical weather prediction model give valuable information about the height of the 0°C isotherm and the snowfall limit. Apart from the implementation in an operational software environment, the validity of the designated hydrometeor type has to be proven. Concerning this, established point measurement devices like optical disdrometers are chosen for indicating the ground truth. After a short summary about the weather radar systems and the optical disdrometers, a brief outline of the hydrometeor classification algorithm is given, highlighted by a case study. In the following, the verification outcomes will lead to the conclusions of this study.

SP3.3: Demonstration of Simultaneous Quad-Polarization for Extended Targets in MIMO-SAR

Tobias Rommel, Marwan Younis, Gerhard Krieger
German Aerospace Center (DLR), Germany
Time: 16:40 -17:00

Due to a high demand for global Synthetic Aperture Radar (SAR) data sets, recent spaceborne sensors reach their limits in terms of resolution, swath-width and repeat cycle. In addition, fully polarimetric operation reduce the maximum swath-width approximately by the factor of two. To solve SAR inherent limitations, a new generation of sensors with multiple transmit and multiple receive channels (MIMO) and digital beam-forming (DBF) capabilities is suggested. Using a quadpolarized MIMO-SAR, transmitting simultaneously orthogonal waveforms in horizontal and vertical polarization, enables data acquisitions without any reduction of the swath-width or resolution. In the underlying paper a concept is described, which uses an advanced filtering and processing method to separate the overlaid transmit signals and to measure all four parameters of the scattering matrix simultaneously. Ground-based MIMO-SAR measurement results are presented, which serve as a first verification of the suggested technique with an extended target.

SP3.4: Investigation of polarimetric multiparameter intrapulse modulation for radar applications and its impact on the detection capabilities

Ingo Klein, Dirk Fischer
Münster University of Applied Sciences, Germany
Time: 17:00 -17:20

Session: 'Aspects of Multi-Parameter Radar Systems and their Signal Processing with reference to Wave Propagation and Scattering effects'(Organisation M. Chandra für ITG

FA 7.5) Abstract: This paper describes the software-defined polarimetric transmitting-pulse generation and receive-signal evaluation of the Digital Beamforming Weather Radar (DBWR), which is currently being developed at the Münster University of Applied Science. The basic architecture of the DBWR, its signal paths and signal processing, as well as the polarimetric multiparameter intrapulse modulation-techniques of the transmitting-pulse and the possibilities to evaluate the received signal are presented. Particular attention is paid to the impact of the different intrapulse modulations on the detection capabilities. The possibilities of modulation includes the intrapulse modulation of the amplitude, frequency, phase and polarization, defined by several arbitrary functions. The modulation of the polarization is defined by the parameters of the polarization ellipse and can be tuned within the transmitting pulse. All modulations can be defined and specified in software, to generate the complete transmitting-pulse in the simple form of a look up table (LUT) which can be transmitted in the signal-processing unit of a SoC-Based FPGA. The signal processor is responsible for the subsequent processing, the implementation of the phased-array functionalities and the output of the transmitting-signal at an intermediate frequency of 44 MHz. By mixing the generated signal with a direct digital synthesis (DDS) signal in a FPGA which is variable in phase and amplitude, it is possible to implement and calibrate the phased-array functionality without any influences on the modulation. The successive RF-Front-End is responsible for the up- and down-conversion, filtering and amplification of the X-Band-Radar frequencies (9470 MHz). The raw data of the received signal can be returned to software. With the known modulation and the phase-/amplitude-offsets of the mixed signal, the evaluation of it can be done in various ways to determine the most effective algorithm for the single receive-signal parameters. Every receive signal can be related to a reference shape of the transmitting pulse in order to find a common measure of comparison

PO2: Interactive Poster Session 2

Chair: Nils Pohl (Fraunhofer FHR, Germany)
Room: Foyer
Time: 09:50 – 10:10 and 11:50 – 12:50

PO2.1: Enhanced Physical Layer Security Using Monopulse Antennas

Adam Narbudowicz[1,2], Korbinian Schraml[2], Max James Ammann[1], Dirk Heberling[2]
[1]Dublin Institute of Technology, Ireland; [2]RWTH Aachen Universität, Germany;

The paper proposes a new method for private point-to-point communication. It employs a monopulse antenna system, where the summary beam is used to transmit the useful signal to the intended receiver, while the differential beam is used to generate noise, in order to bury the signal for angles other than boresight. The method is tested using simulated QPSK modulation, providing a beamwidth with bit error rate below 10-4 within ±6°, while raising BER steep to 0.5 at 32°.

PO2.2: Radar-based Detection of Birds Near Wind Energy Plants: First Experiences from a Field Study

Jochen Moll[1], Moritz Mälzer[1], Nikolas Scholz[1], Viktor Krozer[1], Manfred Dürr[2], Dimitry Pozdniakov[3], Rahmi Salman[3,4], Ralp Zimmerman[3], Markus Scholz[5]
[1]Goethe Universität Frankfurt am Main, Germany; [2]Volta Windkraft GmbH, Germany; [3]HF Systems Engineering GmbH & Co. KG, Germany; [4]Hübner Holding GmbH, Germany; [5]Wölfel Beratende Ingenieure GmbH + Co. KG, Germany

Bats and birds are at risk when they are flying near wind energy plants (WEP). Hence, a protection of bats and birds is postulated to reduce its mortality e.g. due to collisions with the rotorblades. This paper reports on the first experiences from an experimental field study at a 2MW-WEP that combines a 24~GHz Doppler radar, a smart-camera, an ultrasound microphone and an accelerometer. Radar measurements for the identification of birds in their natural habitat will be presented and validated with the camera-based approach

PO2.3: High-speed Start-up and Low-power Decoding Circuit for Wireless Sensor Networks

Hitoshi Hayashi
Sophia University, Japan

A high-speed start-up and low-power decoding circuit for wireless sensor networks is presented. The Manchester code that is currently used for Ethernet (10BASE-T), noncontact IC cards, and RFID systems, requires a phase-locked loop because intervals of the state transition change. In the proposed circuit, state transitions occur periodically at the center of a waveform owing to the use of an encoding method involving several waveforms.

PO2.4: Optically Transparent and Circularly Polarized Patch Antenna for K-Band Applications

Quang Huy Dao, Tracy Jepkoech Cherogony, Bernd Geck
Leibniz Universität Hannover, Germany

This contribution presents an optically transparent and circularly polarized patch antenna to be integrated on a solar cell. The whole configuration is suitable to be use in a wireless sensor node acting as a communication interface and a power source. The antenna consisting of grid lines is studied concerning the impedance behavior due to the applied mesh. A single fed truncated corners meshed patch antenna with meshed ground plane on quartz glass is investigated. This structure with an overall transparency of 91 % has antenna properties comparable to the opaque counterpart. Additionally, the alignment errors between both meshed layers possibly caused by the fabrication process is addressed concerning the axial ratio. A prototype is realized and measured to verify the simulation results.

PO2.5: Performance of Mobile Base Station using Genetic Algorithms in Wireless Sensor Networks

Nurul Adilah Abdul Latiff, Idrus Salimi Ismail
Universiti Malaysia Terengganu, Malaysia

Wireless sensor network is composed of large number of sensor nodes and base station. The sensor node usually is irreplaceable and powered by limited power supply. Taking the fact into consideration, a network should operate with minimum energy as possible to increase lifetime of network for improving the overall energy efficiency. In this work, we proposed a protocol for mobile base station using Genetic Algorithms to find optimal position for base station from virtual base station locations called predetermined locations of base station. Simulation results for performance of the proposed protocol in term of normalized network lifetime shows that the larger size of network field, the lower value for normalize lifetime. The results also show that there are minimum numbers of predetermined locations of base station required for larger network field in order for sensor nodes able to transmit their data to base station.

PO2.6: Spatial Smoothing for Coherent MIMO Radar Setups with Minimum Redundancy

Andreas Kirschner[1], Jürgen Detlefsen[1], Wim Mees[2]
[1]Technische Universität München, Germany ; [2]RMA, Belgium

This paper covers coherent MIMO radar with collocated antennas linked to minimum redundancy principles. The fundament of the first are virtual arrays which can be considered as a discrete convolution of transmitter and receiver distributions. This technique can be connected to sparse arrays regarding minimum redundancy (MR). However, a MR setup is usually feasible for so-called uncorrelated signal scenarios, whereas coherent MIMO radar setups usually provide correlated or coherent signal outputs (with respect to angular processing). The standard angular signal processing of MR arrays would become corrupted in coherent signal case. The spatial smoothing algorithm can provide a possible solution for this conflict. However, the pure amount of required lateral shifts would make the idea of sparse arrays obsolete. Therefore, the spatial smoothing algorithm was adapted by the authors in order to find also sparse lateral shift positions. The answer could again be found in the ideas of minimum redundancy. This paper presents simulation results which were generated during design of radar sensors.

PO2.7: RCS Measurements of a Human Hand for Radar Based Gesture Recognition at E-band

Philipp Hügler, Martin Geiger, Christian Waldschmidt
Universität Ulm, Germany

This paper presents monostatic RCS measurements of a human hand in the frequency range from 60 GHz to 90 GHz. These values are important parameters for system designs in the emerging field of radar based gesture recognition. The measurement procedure is described in detail and results of four gestures at three different distances are depicted and analysed.

PO2.8: Methods and apparatus for microwave thermotherapy based on slow-wave systems

Andrey Albertovich Yelizarov[1], Ruslan Varisovich Shaymardanov[1], Yuriy Nikitich Pchelnikov[2]
[1]Moscow Institute of Electronics and Mathematics, NRU Higher School of Economics, Russia; [2]SloWaves Inc., USA

One of the perspective directions of slow wave systems usage is possibility of their implementation in biology and medicine as antennas and radiators for radio-frequency and microwave physical therapy, a radiothermy and a tomography, sensitive elements for medical diagnostics, devices for sterilization and heat treatment. Advantages of slow wave systems usage in biology and medicine are based on electrodynamic and design features of structures which follow from distribution of an electromagnetic field near their surfaces. Here we are looking for features for usage of slow wave systems on area with high value of dielectric permeability, in particular to biofabrics, and also the problems related to creation of electrodes for intracavitary microwave physical therapy on slow wave systems with primary concentration of electric field in biofabrics, adjacent to electrode surface. In this article the results of modeling microwave radiator on the basis of a ribbed coaxial line were received using Ansoft HFSS v.12 and CST Microwave Studio 2011 software.

PO2.9: Design of a Switched Injection-Locked Oscillator as an Active Backscatter Transponder for a 2.45GHz FMCW Radar System

Markus Schulz, Niko Joram, Christoph Tzschoppe, Frank Ellinger
Technische Universität Dresden, Germany

This paper presents a fully integrated active backscatter transponder for the use in a FMCW radar system for localization of passengers in sea in case of a ship sinking emergency. The active reflector tag is based on a cross-coupled oscillator circuit topology operating as a switched injection- locked oscillator (SILO). The circuit was implemented in a 180nm BiCMOS technology. Measurements resulted in an output power of 12.6dBm while consuming a DC power of 69mW, thus achieving a high efficiency of 26%. Furthermore, the frequency tuning range is 18%, the start-up time is 5.5ns.

PO2.10: Metamaterial-based frequency selective surface with a band gap electronic adjustment

Andrey Albertovich Yelizarov[1], Alexander Sergeyevich Kukharenko[2]
[1]Moscow Institute of Electronics and Mathematics, NRU Higher School of Economics, Russia ; [2]SRUSI, Russia

Currently, frequency selective surfaces, based on metamaterials are increasingly important in microwave technique. The mushroom-type metamaterial surfaces allow solving such tasks as isolation of elements in antenna arrays, multipath mitigating in GNSS systems, reduction of the ground plane edge influence on the directivity of the antenna elements etc. The usage of these structures in the microwave devices design can significantly improve their properties and performance. Structurally mushroom-type metamaterials are periodic microstrip structures and their properties depend strongly on the parameters of the substrate and the accuracy of manufacturing of the conductive pattern. As these structures have a narrow band gap, expensive materials and high precision technologies should be used for their manufacturing. A method of the mushroom-type metamaterial band gap electronic readjustment is proposed in this paper. The idea of the method is that a variable-capacitance diode, should be placed between two coupled mushroom hats one terminal of which is grounded for direct current through a metalized via of the metamaterial element, and the other one is connected to a controlled DC voltage source. At the same time the mushroom hats are separated by at least two capacitive gaps, one of which is in parallel with a variable-capacitance diode, which equivalent capacitance is determined by the DC voltage of the controlled source. The design of a band gap metamaterial-based frequency selective surface with an electronic readjustment of the working band, and the results of its numerical modeling, which show the working band frequency movement while the changing of the lumped elements capacitance are presented. The calculation of the structure dielectric parameters, which confirms that the proposed structure is a metamaterial, is provided.

PO2.11: Influence of the Wafer Chuck on Integrated Antenna Measurements

Linus Boehm, Markus Hehl, Christian Waldschmidt
Universität Ulm, Germany

For meaningful pattern measurements of integrated antennas the devices, which are required during the measurement process, need to be optimized to influence the measurement results as little as possible. In this paper the errors caused by reflections on the chuck are investigated and quantified. A plastic chuck was built to reduce sources of reflection and thus improve the overall accuracy of the setup. The new chuck causes less ripples over the scanning angle and over the frequency and therefore, increases the performance of the setup significantly.

PO2.12: Novel DGS Shape for Mutual Coupling Reduction

Adham Hemdan, Abdelmegid Allam
German University in Cairo, Egypt

This paper presents a MIMO antenna system configuration. The paper is devoted to minimize the mutual coupling between antennas fed from different ports with the use of DGS structures. The paper discusses the system with and without introducing a novel DGS shape. The antennas are operating at 5GHz (Wi-Fi application). It contributes a mutual coupling reduction up to 14.4 dB. The antenna configuration is fabricated. It conducts a good agreement between the measured and simulated scattering coefficients. The antenna gain, pattern and current density are nearly unchanged for the different configurations.

PO2.13: An Integrated 118.4-122 GHz Low Noise Phase Locked Loop (PLL) in 0.13 µm SiGe BiCMOS Technology

Umair Ali, Martin Bober, Andreas Thiede
Universität Paderborn, Germany

Design of a PLL based frequency synthesizer which is able to provide signals over the frequency bands 118.4-122 GHz, 59.2-61 GHz, and 29.6-30.5 GHz is presented in this paper. A fundamental voltage controlled oscillator (VCO) and two high speed divide by two frequency divider stages are used to cover all three frequency ranges. The first divider stage is a digital dynamic divider while second stage is a static frequency divider. The measured PLL phase noise is -95 dBc/Hz at an offset of 100 KHz from 30 GHz output. The circuit is fabricated in IHP 0.13 µm SiGe BiCMOS technology with ft and fmax of 300 GHz and 500 GHz, respectively. The whole PLL occupies chip area of 0.7 mm2. The total DC power consumption of the PLL is 0.93 Watt.

PO2.14: Integrated, 16 - 21GHz Marchand Balun in 65nm CMOS

Ahmed Hamed, Mohamed Elsayed, Renato Negra
RWTH Aachen Universität, Germany

This paper presents the design and implementation of an integrated wideband Marchand balun in standard 65nm CMOS technology. The proposed balun operates from 16 GHz to 21 GHz achieving high coupling together with significantly low phase and amplitude imbalance between the balun outputs. A new balun structure is proposed to solve the nonideal ground problem in CMOS-based microwave circuits, and coherently enables the injection of DC signal to bias the consecutive circuits. The proposed prototype is implemented in TSMC 65nm 1P9M standard CMOS technology occupying total area of 280 um X 310 um, and achieves maximum phase variation of +/-2deg, and maximum amplitude imbalance of 2 dB which makes it suitable for wideband microwave applications.

PO2.15: An Adaptive Biasing Method for SRD Comb Generators

Thomas Harzheim[1], Holger Heuermann[1], Michel Marso[2]
[1]FH Aachen, Germany; [2]Université du Luxembourg, Luxembourg

This paper presents an adaptive biasing method for step recovery diode based comb generators under MATLAB control. The aim is to provide the maximum possible harmonic output power for a given configuration for different input frequencies under input power variation, increasing the usefulness of comb generators as harmonic phase reference sources for nonlinear VNA measurements in the millimeter wave range. The effects are studied on a SRD comb generator which is able to generate -20...30 dBm harmonics in the 50 to 60 GHz range while under wideband termination. It is shown that depending on input power and frequency, different bias level behaviors for maximum harmonic output power over frequency exist and data for maximum power level bias is provided for output frequencies up to 60 GHz. Furthermore the effect of subharmonic comb frequency generation is demonstrated.

PO2.16:A Practical Approach for RF Circuit Size Reduction

Xuan Anh Nghiem, Renato Negra
RWTH Aachen Universität, Germany

In this paper, a practical approach to circuit miniaturisation using periodically loaded transmission lines is presented. A full investigation of T- and -shaped unit cells that constitutes periodic structures (PS) has been conducted, leading to a straightforward method for miniaturizing passive RF/Microwave circuits and components. For the completion of the design method, the normalised 3 dB cutoff frequency of unit cells has been thoroughly studied, providing a guideline for optimum structure parameters that meet the required bandwidth while ensuring a reasonable size reduction ratio. For demonstration, a broadband power divider/combiner with a frequency band of 1.0-3.0 GHz has been implemented, showing very good performance with a size reduction of about 47% compared to the conventional design.

PO2.17: Fundamental Limitations of Crystal Oscillator Tolerances on FMCW Radar Accuracy

Mohammed El-Shennawy, Belal Al-Qudsi, Niko Joram, Frank Ellinger
Technische Universität Dresden, Germany

Crystal oscillators (XOs) are widely used in fractional-N phase locked loops (Frac-N PLLs) as reference frequency sources due to their good phase noise performance. However, these XOs have manufacturing tolerances in the range of few tens of parts per million (ppm). When a Frac-N PLL is used in frequency modulated continuous wave (FMCW) radar applications, the XO accuracy affects the frequency and timing accuracies of the radar chirps and so it directly affects the distance measurement accuracy. In this work, the fundamental limits of XO tolerance on distance measurement accuracy of FMCW radars are discussed and modelled. Moreover, an FMCW radar system hardware prototype is developed. Measurement results are in good agreement with the expectations of the simulation model.

Wednesday, 16 March 2016

Time	Foyer	HID	HIC	ID 04/445	ID 03/471	ID 04/459+471
08:00–08:30	Registration					
08:30–10:10		S12: Radar and TDR Systems	S13: Electromagnetic Engineering		EUMW Team Meeting 2017	
10:10–10:30		Coffee Break				
10:30–12:10		S14: Power Amplifier 2	S15: Material Characterization	WS5: Intel Industrial Workshop		DFG Diskussions-Sitzung
12:10–13:30		Closing Session, Award Ceremony (HID)				
13:30–14:00		Lunch Break				
14:00–17:10					Doctoral School until Thursday afternoon	Meeting HF-Professors until Thursday afternoon
17:10–18:00						

S12: Radar and TDR Systems

Chair: Christoph Scheytt (Universität Paderborn, Germany),
Stephan Stanko (Fraunhofer FHR, Germany)

Room: HID Time: 08:30 – 10:10

S12.1: Determining Linearity of Wideband FMCW-Systems Based on Low-Cost Six-Port Technology

Sascha Wibbing, Fabian Lurz, Sebastian Mann, Stefan Lindner, Sarah Linz, Robert Weigel, Alexander Kölpin
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Time: 08:30 -08:50

This paper describes a new method for high accuracy determination of instantaneous frequency and linearity of frequency modulated continuous wave systems. The presented setup reduces the frequency measurement to a phase measurement based on Six-Port interferometer with a delay line. To extend the range of possible input frequencies and power levels, a calibration method and the appropriate correction algorithm is introduced. Evaluation of linearity and frequency of the input signal is obtained without the use of computationally intensive Fourier transform which allows the signal processing based on low-cost micro-controllers.

S12.2: Spectral Properties of Time Domain Reflectometry Systems

Robert Storch[1], Michael Gerding[2]
[1]Krohne Innovation GmbH, Germany; [2]Krohne Messtechnik GmbH, Germany
Time: 08:50 -09:10

Time domain reflectometry (TDR) systems are widely used to perform accurate distance measurements. The crucial component that determines accuracy and repeatability within these systems is the timebase. For an optimal design it is mandatory to have a precise knowledge about the impact of errors within the timebase on the measurement result. Besides the influence of stochastic errors this paper mainly deals with the analysis of deterministic errors. A mathematical model will be derived which can be used to optimize timebases only by means of the spectral properties of the signals. This model is compared to measurement results verifying the usefulness of the approach.

S12.3: A Compact, Energy-Efficient 240 GHz FMCW Radar Sensor with High Modulation Bandwidth

Sven Thomas[1], Christian Bredendiek[2], Timo Jaeschke[2], Florian Vogelsang[2], Nils Pohl[1]
[1]Fraunhofer FHR, Germany; [2]Ruhr-Universität Bochum, Germany

Time: 09:10 -09:30

In this paper a highly integrated and compactly built FMCW radar system working at a center frequency of up to 240 GHz is presented. With an ultra wide tuning range of 40~GHz a range resolution down to 3.75 mm based on a -6 dB width of the target peak can be achieved, which enables this radar system for various high precision distance measurement and high resolution imaging applications. With the use of a highly integrated system architecture and on-chip antennas based on a single MMIC in combination with a PTFE lens antenna system, a very robust and compact realization is possible. Due to the full integration of all high frequency components, an open cavity QFN package can be used to mount the MMIC on a cost effective and easy-to-fabricate FR4 substrate, which also allows for quick and easy rework processes or chip replacements. The low power consumption of 3.5 W at a supply voltage of 5 V in addition to the compact, cost effective realization and the high resolution make this radar suitable for industrial applications.

S12.4: An Ultra-Wideband Time Domain Reflectometry Chipless RFID System with Higher Order Modulation Schemes

Maximilian Poepperl[1], Christian Mandel[2], Martin Vossiek[1], Christian Carlowitz[1], Rolf Jakoby[2]
[1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; [2]Technische Universität Darmstadt, Germany

Time: 09:30 -09:50

This paper presents a low-cost, low-complexity FMCW-based ultra-wideband (UWB) chipless time domain reflectometry (TDR) radio frequency identification (RFID) system, which is suitable for implementing higher order modulation schemes. Higher order modulation significantly increases the information content in chipless RFID. The applicability of phase-shift keying (PSK) and pulse-position modulation (PPM) to chipless TDR RFID leads us to introduce an 8-PSK and an 8-PSK-and-2-PPM combination. The overall data capacity is increased to 16 bits compared to low-order modulation schemes, for example, on-off keying, which achieve only 4 bits. The tag, which is based on a meandered transmission line, can be printed cheaply as it consists solely of micro-strip structures. We built an appropriate interrogation unit since the achievable storage density of a chipless RFID tag greatly depends on the reader architecture and performance as well. The reader features a bandwidth of 1.25 GHz at a center frequency of 7.825 GHz, which allows for maximal power to meet most countries' UWB regulations. The reader's interrogation signal is a frequency-modulated continuous-wave (FMCW) signal generated by a voltage-controlled oscillator (VCO) that is stabilized by a phase-locked loop (PLL). With this setup the interrogation-unit build is inexpensive. As the reader as well as the tag impact the information content, the complete RFID system needs to be investigated. In addition to a detailed description of both system parts, tests demonstrate the performance of the TDR RFID systems.

S12.5: Crystal Oscillator Frequency Offset Compensation for Accurate FMCW Radar Ranging

Belal Al-Qudsi, Mohammed El-Shennawy, Niko Joram, Frank Ellinger
Technische Universität Dresden, Germany
Time: 09:50 -10:10

Accurate ranging and positioning systems encounter several practical limitations. Crystal oscillator (XO) tolerance is a major challenge that impairs the accuracy of these systems. Two-way ranging with frequency modulated continues wave (FMCW) radars in particular are more influenced by XO tolerance as compared to primary FMCW radars. So this work focuses on the measurement and compensation of the relative frequency offsets between the different XOs in FMCW radar systems in order to improve their ranging accuracy. With a two-way ranging synchronization protocol, a ±1 part per million (ppm) relative XO frequency offset may translate to ranging errors in the range of ±1.2 m. In this work, a three-way ranging synchronization protocol is proposed to compensate for the relative XO offset. The approach was tested in a practical ranging setup. Compared to the conventional two-way ranging synchronization protocol, the ranging precision was enhanced by a factor of around 2.

S13: Electromagnetic Engineering

Chairs: John Jelonnek (Karlsruhe Institute of Technology, Germany),
Dirk Manteuffel (Universität Kiel, Germany)
Room: HIC Time: 08:30 – 10:10

S13.1: Probe-Receiver Coupling in External Calibration Systems

Nhat Minh Pham, Arne Jacob, Ridvan Akpinar
Technische Universität Hamburg-Harburg, Germany
Time: 08:30 -08:50

On-line calibration systems with near-field probes are an attractive approach for a large-size DBF array. In order to improve the calibration accuracy, a model of the coupling between the receiver patch and the calibration monopole probe is developed further in this contribution. A Fourier-based approximation of the radiation characteristic of the patch is proposed as a compromise between accuracy and computational effort. A planar array is built to validate the proposed concept. A phase error of 1.5° and an amplitude deviation of 0.8 dB are achieved in the experiments.

S13.2: Side-lobe Reduction of Horn Antenna Using Circular Patch Mushroom-Like EBG Structure

Tanan Hongnara[1], Korbinian Schraml[2], Sarawuth Chaimool[3], Prayoot Akkaraekthalin[1], Dirk Heberling[2]
[1]King Mongkut's University of Technology North Bangkok, Thailand; [2]RWTH Aachen Universität, Germany; [3]Udon Thani Rajabhat University, Udon Thani
Time: 08:50 -09:10

This paper presents an reconfigured horn antenna for side-lobe reduction by using an electromagnetic band gap (EBG) structure. A mushroom-like structure as unit cell is used and designed to achieve completely EBG with circular shape resonator. It is lined on two wall sides in the E-plane of the conventional horn antenna. Obviously, the EBG surface can suppress and obstruct surface waves on the metallic plate of horn antenna, resulting in side-lobe suppression over the designed EBG. In addition, the proposed antenna can be suitable for high power systems due to a purely metallic construction in EBG surface.

S13.3: Far Field Analysis of Wrinkles in Space Membrane Antennas

Ralf Wilke, Korbinian Schraml, Dirk Heberling
RWTH Aachen Universität, Germany
Time: 09:10 -09:30

Large deployable antennas (LDA) are an upcoming technique used as space borne reflector antennas. Low stow volume and mass are one of the key advantages allowing big reflector diameters to be launch on conventional vehicles. A primary concern in reflector antenna building is surface accuracy, especially at high operating frequencies. Conventional LDA use sophisticated high cost mechanics to deploy a mesh structure with low surface error. But deployable structures are also used as a drag sail to deorbit satellites when their live time is exceeded. The surface structure of such a drag sail is of subordinate interest, leading to low cost and deployment mechanics, which are easy to build. The idea described in this paper is to use the drag sail deployment technique and use the expanded membrane surface as a reflector antenna. The effects of the surface errors, which are inevitable introduced by the mechanics, are studied to help to determine a break-even point between antenna performance loss and cost reduction compared to a conventional LDA. Possible applications are small satellites like CubeSats, which could enhance their communication link budget by deploying a medium performance but low cost LDA.

S13.4: Self-Calibration of Differential Cable-Adapters with Intra-Mode Crosstalk

Sebastian Wagner, Stephan Kolb, Reinhard Stolle
Hochschule Augsburg, Germany
Time: 09:30 -09:50

A new solution for the calibration of a multiport vector network analyzer (VNA) is presented, in order to measure the mixed-mode scattering parameters (S-parameters) of a 4-port device under test (DUT). The calibration procedure accounts for coupling between identical modes (intra-mode) of (modal) ports, whereas different modes are assumed to be decoupled (inter-mode). The new method is an extension of known procedures for leaky 4-port error-networks together with two extensions of the well-known unknown-thru procedure. Among others, it requires application of a mode-conversion standard, which can be a reciprocal yet otherwise unknown device.

S13.5: 09:50 Measured Impact of Electromagnetic Scattering off Wind Turbines on Broadcast Signal Propagation

Christian Bornkessel, Sindy Schulze, Matthias Hein
Technische Universität Ilmenau, Germany
Time: 09:50 -10:10

The electromagnetic scattering pattern of a wind turbine at DVB-T and DAB frequencies was studied by measurement on a scaled laboratory model, taking into account different yaw and pitch angles, and blade positions. The scattered energy peaks along backward directions, where it is stronger for vertical than for horizontal polarization, and is dominated by the mast. The variation of the yaw angle has greater effect compared to blade and pitch variations. Illuminating the wind turbine from the back results in stronger scattering compared to the front side due to the aerodynamic cross-sectional shape of the blades. The scattering becomes stronger for increasing electrical size of the wind turbine. The experimental approach proves reliable and helpful for the development of propagation models.

S14: Power Amplifier 2

Chairs: Renato Negra (RWTH Aachen Universität, Germany),
Michael Schlechtweg (Fraunhofer IAF, Germany)
Room: HID Time: 10:30 – 12:10

S14.1: A 500W High Efficiency Class-E Power Amplifier for Heating a Variable Plasma Load at 10MHz

Gordon Notzon, Thomas Busch, Marcel van Delden, Thomas Musch
Ruhr-Universität Bochum, Germany
Time: 10:30 -10:50

In this contribution, a high efficiency class-E power amplifier is presented, which is optimized with respect to heat a variable plasma load at 10MHz. First of all, the design of the class-E amplifier is demonstrated. Therefore, after the fundamental design equations, the dimensioning of amplifier's lumped elements is presented. Furthermore, simulations and measurements are performed in order to verify the functionality and efficiency. During this, two high power MOSFETs from Microsemi and IXYS are compared. An efficiency of 90.7% at 507W output power and 50Ω load is achieved. The resistance of the plasma load can change between 200Ω and 300Ω. Therefore, an optimized matching network, which provides an almost constant output power of ±1% in the desired load resistance range, is presented.

S14.2: A low power CMOS transmitter with Class-E power amplifiers for positioning application in multi-band

Chia-Yu Hsieh, Jürgen Roeber, Andreas Baenisch, Amelie Hagelauer, Robert Weigel
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Time: 10:50 -11:10

In this paper, a transmitter for outdoor positioning application such as animal tracking is introduced. Class-E power amplifiers are exploited in the TX system in order to increase the energy efficiency for the demand of long operation duration of the system. Along with the need of power saving, a circuit topology is proposed to realize the modulation based on Binary Offset Carrier (BOC) technique at two different bands to achieve higher positioning accuracy and better utilization of the spectrum by transmitting data simultaneously. The operating frequencies of the system are 868 MHz and 2.4 GHz, and the circuit is designed in 150 nm CMOS technology. The power efficiency of the class-E power amplifier is greater than 50 % over 2.4-2.8 GHz while the measured output power is greater than 10 dBm from 1.2 to 2.8 GHz.

S14.3: Wideband 80 W Balanced Power Amplifier for ISM and LTE-Bands

Sophie Paul, Sebastian Preis, Wolfgang Heinrich, Olof Bengtsson
Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany
Time: 11:10 -11:30

In this paper, an 80 W balanced GaN-HEMT power amplifier for 2.45-2.70 GHz using branch-line couplers is presented. Its performance is compared to a single-transistor solution. The analysis shows that a balanced amplifier is favorable because it simplifies measures to ensure electrical stability and allows better heat sinking.

S14.4: Reliable GaN HEMT Modeling Based on Chalmers Model and Pulsed S-Parameter Measurements

Peng Luo[1], Olof Bengtsson[1], Matthias Rudolph[2]

[1]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany;
[2]Technische Universität Cottbus, Germany
Time: 11:30 -11:50

GaN HEMT performance is still compromised by trapping effects, but no commercial circuit simulator already provides compact models that account for these effects. This work explores the capability of a standard Chalmers (Angelov) model to accurately predict the power amplifier operation of GaN HEMTs. It is shown that relying on pulsed S-parameters and by restricting the model to be valid only for a fixed drain voltage, good simulation accuracy is achieved.

S14.5: VSWR Protection of Power Amplifiers Using BST Components

Jérôme Ferretti, Sebastian Preis, Wolfgang Heinrich, Olof Bengtsson
Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany
Time: 11:50 -12:10

A VSWR-protected ISM-band PA was realized using a BST based varactor for detuning of the input matching. Output VSWR levels of 30:1 can be tolerated by applying a varactor bias voltage of up to 20 V. The PA delivers 47.4 dBm output power at a maximum PAE of 49.5%. In case of high VSWR conditions the output power can be limited by detuning the varactor. It is shown that the concept protects the transistor efficiently with very low additional circuit complexity.

S15: Material Characterization

Chairs: Christian Damm (Technische Universität Darmstadt, Germany),
Jörg Schöbel (Technische Universität Braunschweig, Germany)

Room: HIC   Time: 10:30 – 12:10

S15.1: Monostatic and Thickness-Independent Material Characterisation based on Microwave Ellipsometry

Jan Barowski[1], Thorsten Schultze[2], Ingolf Willms[2], Ilona Rolfes[1]
[1]Ruhr-Universität Bochum, Germany; [2]Universität Duisburg-Essen, Germany
Time: 10:30 -10:50

Material characterization utilizing microwave ellipsometry is based on the fact that the reflection coefficents of a wave impinging on a material depend on the incident fields polarization. Due to multiple reflections that occur in case of a material slab with finite dimensions these coefficients also strongly depend on the materials thickness. This paper describes an approach to determine the electromagnetic properties of a material under test by applying an ellipsometric measurement without knowledge of the materials thickness. The paper shows that the additional measurement of the transmission coefficents allows to perform an exact measurement of the complex permittivity since the thickness dependencies in reflection and transmission coefficents cancel each other. The measurements are done in the frequency range from 22 GHz to 26 GHz by using a vector network analyzer setup with a conical horn antenna.

S15.2: Dielectric Permittivity Determination in W-Band with Dielectric Ring Resonators

Janis Häseker, Steffen Vogt, Martin Schneider
Universität Bremen, Germany
Time: 10:50 -11:10

In this work we are using a ring resonator made of dielectric waveguide (DWG) to determine the complex permittivity of the waveguide's material. The proposed method offers high precision and low complexity at millimetre wave frequencies compared to established methods like the Fabry-Perot Resonator. This set-up is especially useful to find the tan δ of materials with low dielectric losses. Similar measurement techniques are known at optical frequencies, but little work has been done using them in the millimetre wave bands. The theory of the ring resonator and the measurement set-up are presented and the approach for the determination of ε_r and tan δ is explained. Different materials are analysed and values of their complex permittivity are compared to literature.

S15.3: A Grounded Coplanar Waveguide Resonator Based In-Line Material Characterization Sensor

Armin Talai, Sebastian Mann, Robert Weigel, Alexander Kölpin
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Time: 11:10 -11:30

Microwave Materials such as Rogers RO3003 are subject to process-related fluctuations in terms of the relative permittivity. The behavior of high frequency circuits like patchantenna arrays and their distribution networks is dependent on the effective wavelength. Therefore, fluctuations of the relative permittivity will influence the resonance frequency and antenna beam direction. This paper presents a grounded coplanar waveguide based sensor, which can measure the relative permittivity at 77GHz, as well as at other resonance frequencies, by applying it on top of the manufactured depaneling. In addition, the sensor is robust against floating ground metallizations on inner printed circuit board layers, which are typically distributed over the entire surface below antennas.

S15.4: Measurement of Complex Permittivity of Anisotropic Dielectric Spheres

Daniel López Cuenca, Rajpal Dudi, Jan Hesselbarth
Universität Stuttgart, Germany
Time: 11:30 -11:50

A new concept to measure the dielectric properties of anisotropic spheres at microwave frequency is presented. First, the sphere is placed in a parallel-plate microstrip structure. The anisotropic axis of the sphere is determined in a three-step process. Then, sphere is placed in a rectangular waveguide cavity resonator, where resonance modes of the sphere are excited and subsequently modeled in a field simulation tool. Simulations are matched with measurements by fitting the anisotropic complex permittivity parameters. The procedure is illustrated by determining the anisotropic axis and measuring the anisotropic complex permittivity of a sapphire sphere of 10 mm diameter.

S15.5: Measurement of Dielectric Properties for Thick Ceramic Film on an Alumina Substrate at Microwave Frequencies

Kouji Shibata, Masaki Kobayashi
Hachinohe Institute of Technology, Japan
Time: 11:50 -12:10

In this study, the mode-matching method was applied to formulate an analytical model for a split cylindrical cavity resonator with a thick ceramic film layer sandwiched between two-layer alumina substrates. Next, resonant frequencies with the TE011 mode were computed with an eigenvalue problem approach using the model formula. The Q value of the resonator was also calculated by applying the perturbation method to the analytical model. The validity of the proposed analytical technique was confirmed using the procedure described below by applying this method to the estimation of complex permittivity for thick film with an inverse problem approach.

Workshops

Monday, 14 March 2016

WS1: Workshop on New Features for Microwave and RF Simulation in CST STUDIO SUITE 2016
Room: ID 04/445 Time: 16:00 – 17:40

Frank Demming-Janssen, Matthias Hansli, Stefan Eller,
CST-Computer Simulation Technology AG

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. CST STUDIO SUITE 2016 introduces several new features for the simulation of both individual components and full systems. This workshop will demonstrate new 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.

WS2: Hands-on-Training: Antenna Simulation with CST STUDIO SUITE 2016 & Antenna Magus

Room: ID 04/445 Time: 08:00 – 09:50

Frank Demming-Janssen, Matthias Hansli, Stefan Eller,
CST-Computer Simulation Technology AG

This workshop gives the participants the opportunity to do some hands on antenna design using CST STUDIO SUITE 2016. As a starting point, the user will consult "Antenna Magus" for some design ideas. As next step, the antenna will be constructed & optimized in CST MICROWAVE STUDIO. TO improve the antenna match, a matching network is designed & optimized in CST DESIGN STUDIO. For a final check, feeding and antenna geometry are combined using CST's advanced System Assembly and Modelling (SAM) workflow for a full 3D EM Simulation.

Space is limited! Please register at the CST booth. First come, first serve!

WS3: ANSYS Industrial Workshop – Efficient EM-Simulation of complex antenna system using advanced methods

Room: ID 04/445 Time: 10:10 – 11:50

Markus Laudien, Lead Application Engineer, Ansys Germany GmbH

Scenarios like antenna placement on vehicles or planes, coupled antennas systems or large antenna arrays are important parts of today´s RF systems. 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 with driving circuits, Domain Decomposition for finite arrays; FE-BI Hybrid solver techniques and usage of coupled asymptotic methods such as SBR the simulation procedure can be strongly improved. Re-use of portions of the mesh can be applied to save time and a new technique called "assembly meshing" can be used for scenarios like scattering of moving objects.

Besides practical example cases like antenna arrays the workshop will address the simulation approaches for antenna placement on larger geometries or coupled antennas. A discussion will point out the advantages and limitation of the simulation techniques for the different applications.

WS4: Simulation based design of innovative antenna arrays

Room: ID 03/139 Time: 14:00 – 15:40

Marta Arias Campo, Thorsten Liebig, IMST GmbH

High efficient & agile antenna arrays become more and more important for applications such as radar, satellite communications, wireless and 5G. For the design of such complex arrays at higher frequencies like e.g. 30 GHz, 60 GHz or 77 GHz, 3D EM modelling has become a crucial design tool, as the RF-structures have become highly complex on such a large scale that hardware design & optimisation by hand has become a thing of the past. This half day workshop gives insight into the design process of innovative antenna arrays using 3D numerical simulations, based on IMST's long-term experience and tools. After a short introduction of the basics of antenna arrays, an interactive session will take place in the Computer Terminal Room of the University of Bochum. The lecturers will guide the participants interactively step by step through a design tutorial of a planar array for 60 GHz Wifi-applications.

WS5: Hands-on-Training: Programming of a first ‘Internet of Things’ Application on an Intel Curie module

Room: *Room: ID 03/139* Time: 10:30 – 12:10

Thomas Tacke, Matthias Weßeling, Intel Deutschland GmbH

The “Internet of Things” is an emerging technology with projections of a huge impact on economy, which are anticipating up to 100 billion connected IoT devices by 2025. Many consumer products will be combined with Internet connectivity and data analysis capabilities.

This workshop will introduce to the programming of simple applications on a development platform with an Intel curie module and several sensors. You will learn the basic development environment, programming interfaces and tools to create your own first applications. Considered examples will connect the device to the Internet or to your mobile phone, which enables a broad range of potential own applications.

Doctoral School

Measurement Techniques

Room: ID 03/471 Wednesday, March 16 14:00 – 19:30

Opening

RUB Research School Organisation Team

Time: 14:00 -14:15

Keynotes

Steffen Heuel, Rohde & Schwarz

Karam Noujeim, Anritsu

Time: 14:15 -16:15

Workshop

Markus Funk, Rohde & Schwarz

Time: 16:15 -18:00

Postersession

Room: ID 03-Magistrale, Time: 18:00 – 19:30

Electromagnetic Simulation

Room: ID 03/471, ID 03/133 Thursday, March 17 09:00 – 13:00

Keynotes

Winfried Simon, IMST

Markus Laudien, Ansys

Time: 09:15 -11:15

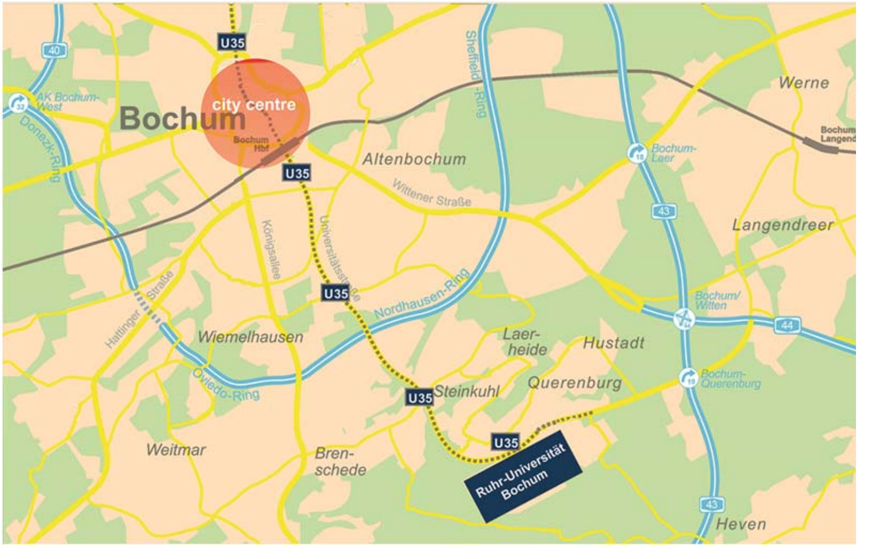
Workshop

Marco Roggero, MathWorks

Time: 11:15 -13:00

Conference venue

The GeMiC 2016 is held at the the Ruhr-Universität Bochum in the building ID. You can reach the Ruhr-Universität, which has its own station, easily from main train station (Hauptbahnhof) Bochum by catching the underground (U-Bahn) train U35 (CampusLinie). On workdays, the U35 (towards Bochum Hustadt) departs in five-minute intervals, and it takes less than 10 minutes to go from the main train station to the university station.

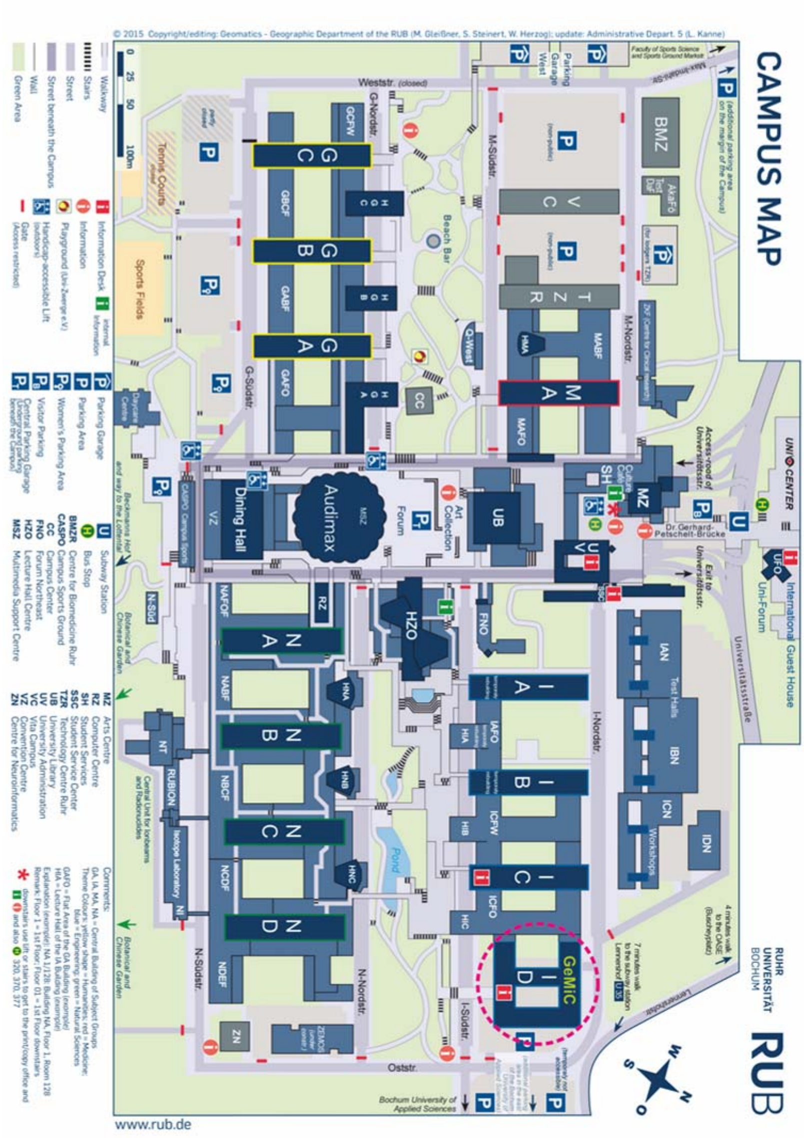


Address of the venue

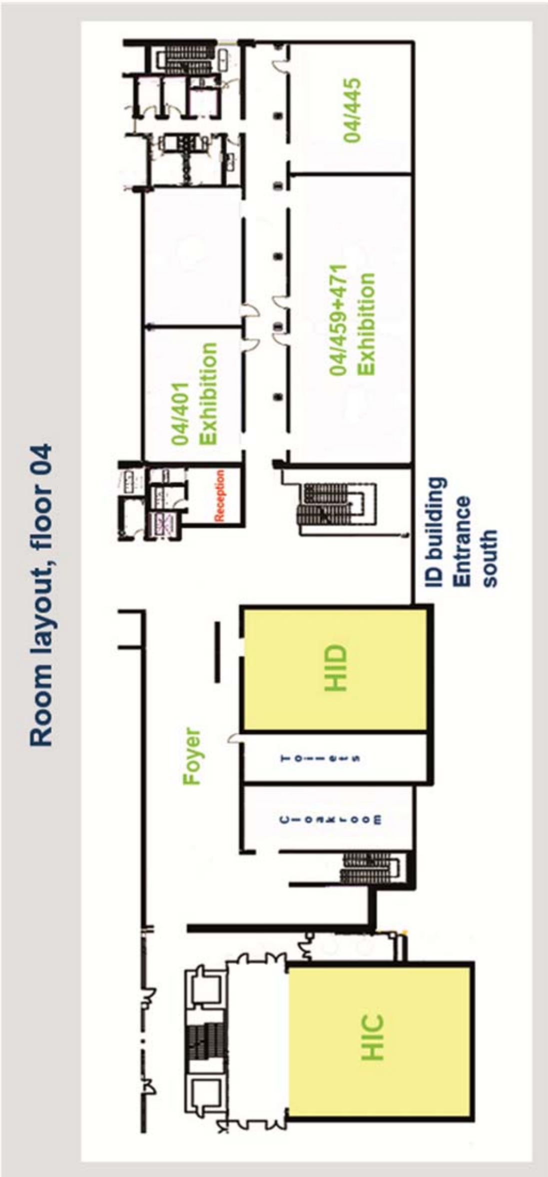
Ruhr Universität Bochum
Building ID
Universitätsstraße 150
44801 Bochum
51.44688 °N, 7.26635 °E
51°26’48.8“ N, 7°15’58.9“ E

Conference Venue

Map of the Ruhr-Universität Bochum



Room layout of the venue



WiFi-Access

For the GeMiC 2016, two different connections are offered.

Access 1

All university buildings are covered by wireless LAN eduroam, which is used in many universities.

You can connect to this network with your standard login.

Access 2

We installed accounts for guests: Please contact the registration desk for getting information.

Welcome Reception

On Monday evening, GeMiC 2016 welcomes you with a reception, which offers a great opportunity to meet colleagues and to share ideas in a convenient atmosphere.

You will also have the opportunity to experience “microwaves” in hands on experiments and talk to industrial partners in an interesting exhibition.

The Welcome Reception starts at six in the evening and ends around nine pm.

Conference dinner

Address of the conference dinner

LWL-Industriemuseum Henrichshütte Hattingen
Werksstraße 31-33
45527 Hattingen
51.40714°N, 7.18763°E
51°24’25.7“ N, 7°11’15.5“ E

How to get to there?

The transfer from Ruhr-Universität to the location of the conference dinner will be done by coach. The participants will be picked up at the below marked meeting point at a quarter to six.

How to get back?

After the evening event the coaches will take you back to the city centre of Bochum near main train station.

Airbus Defence and Space GmbH
www.airbusdefenceandspace.com

Airbus DS *Electronics and Border Security* is a leading global provider of mission-critical sensors, integrated systems and services for premium defence and security applications. As a separate organizational unit within Airbus Defence and Space, it is managed according to arms-length principles and drives the defence electronics and security solutions businesses. It is the world leader in large-scale integrated border security systems, global No.1 in missile warning systems and the German sensor house with a major position in the radar, optronics and electronic warfare markets.

Customers benefit from the business area's strong heritage capitalizing on renowned names such as Telefunken, Dornier and Zeiss. It employs today approx. 5,000 employees generating revenues of more than €1 billion per year. *Electronics and Border Security* is addressing the market via several legal entities. Its portfolio is managed by two Business Units: Defence & Security Electronics and Security Solutions. Its offering covers the following areas: Radar & IFF, Electronic Warfare & Situational Awareness, Optronics, Product Support and Security Solutions. It brings together a wide portfolio providing customers across the world with premium solutions to preserve security and stability.

AlbatrossProjects

Albatross Projects GmbH
Daimlerstr. 17
89564 Nattheim
www.albatross-projects.de

To realize state of the art turn-key projects for Anechoic Chambers and Shielded Rooms Albatross Projects is following the latest changes in test and measurement standards for civil and military applications.

Our solutions for RF rooms, EMC and Microwave test sites are a benchmark for the automotive, telecommunications, electronics, multimedia, test houses, antenna measurements and medical equipment industries. We also supply solutions for full CE compliant EMC tests and measurements.

The Albatross Projects headquarter is located in Nattheim/ Germany and runs subsidiaries in North America (Dallas), P.R. China (Shanghai), India (Hyderabad) and Hong Kong.

Albatross Projects is committed to excellent service.

Anritsu
envision : ensure

Anritsu GmbH
Nemetschek Haus
Konrad-Zuse-Platz 1
81829 Munich
www.anritsu.com

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.

ANSYS Germany GmbH
Birkenweg 14a
64295 Darmstadt
www.ansys-germany.com

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, analysis, simulation and design optimization of antennas, radar cross section (RCS), filters, diplexers, power amplifiers, RF and microwave components
- Harmonic balance, circuit envelope and transient simulation with direct integration with 3-D EM simulators (including FEM, method of moments, integral equation, and transient solvers)
- Thermal and stress analysis based on electrical performance by linking to other products in the ANSYS multiphysics suite
- You can leverage ANSYS RF and microwave design software to model, simulate and validate high-frequency components and antennas found in communication systems, mobile devices, computers, radio and radar. ANSYS software streamlines the transfer of design databases from popular third-party EDA layout tools from Cadence, Mentor, Synopsys, Zuken, Altium and others.

AR Europe
AR Deutschland GmbH
Theodor-Heuss-Strasse 38
61118 Bad Vilbel
Germany
www.ar-deutschland.com

AR Europe's (Amplifier Research) commitment to our customers goes beyond providing the world's most innovative and reliable power amplifiers. We specialize in the supply of test equipment and turnkey systems for RF & Microwave, EMC, Electrical Safety, Power Electronics as well as EMC Test Chamber and Shielded Enclosures. Our network of experienced sales associates and service technicians allow us to provide the best solution for our customers' requirements as well as local training, installation, repair and maintenance support.

bsw TestSystems & Consulting
Waldenbucher Str. 42
71065 Sindelfingen
www.bsw-ag.com

bsw TestSystems & Consulting is specialized on RF & µw-components and Test & Measurement Solutions. The core competency spreads from On-Wafer-Characterisation of RF and DC/CV -Parameters to Signal Integrity Applications. The bsw TestSystems & Consulting thus offers the whole RF-range from components via instruments up to complex solutions from one source.

Carl-Cranz-Gesellschaft e.V.
Postfach 1112
82230 Weßling
www.ccg-ev.de

For more than fifty years, the academy has been dedicated to offering courses for lifelong learning in engineering and science. Our more than 100 courses per year impart up-to-date, practice-oriented knowledge. The courses take place in our center in Oberpfaffenhofen Germany, at other locations and on demand as Inhouse-Courses. The courses are in German, courses in English are available as well. The duration is one to five days. Since 1963, more than 50,000 national and international participants have attended our courses. Topics offered range from introductions to new fields through comprehensive presentations of principles to in depth treatment of special topics and the latest results in the fields of research, development and applications. The Carl-Cranz-Academy is a non-profit organization.

CST - Computer Simulation Technology AG
Bad Nauheimer Str. 19
64289 Darmstadt
www.cst.com

Founded in 1992, CST offers the market's widest range of 3D electromagnetic field simulation tools through a global network of sales and support staff and representatives. CST develops CST STUDIO SUITE, a package of high-performance software for the simulation of electromagnetic fields in all frequency bands, and also sells and supports complementary third-party products. Its success is based on a combination of leading edge technology, a user-friendly interface and knowledgeable support staff. CST's customers are market leaders in industries as diverse as telecommunications, defense, automotive, electronics and healthcare. Today, the company enjoys a leading position in the high-frequency 3D EM simulation market and employs 250 sales, development, and support personnel around the world.

EMCO Elektronik GmbH
Bunsenstrasse 5
82152 Planegg
www.emco-elektronik.de

EMCO Elektronik GmbH presents itself as an exclusive technical sales representative and value-added partner for electronic components, instruments and measurement techniques in the application areas EMC, RF, Microwave, SATCOM & Space; our portfolio ranges from pure component technology (active and passive) to complex, customized measuring devices. For example we deliver broadband amplifier systems and modules, high-frequency counter, programmable and adjustable attenuators, circulators, oscillators, pulse generators, microwaves, cables, bias tees, DC blocks, coaxial components, calibration kits, power meter, signal generators, noise generators, coaxial - & waveguide adapters, waveguide trains, test port cables & connectors, sliding loads, fiber optic data transmission systems up to complete customized laboratories.

Our objective is the expert advice & recording of complex customer requirements and the development of efficient and cost-oriented solution concepts.

Fraunhofer FHR
Fraunhoferstraße 20
53343 Wachtberg
www.fhr.fraunhofer.de

The Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR develops concepts, methods and systems for electromagnetic sensor technology, particularly radars, implementing modern methods of signal processing and innovative technologies, ranging from microwaves to the lower end of the terahertz band. With a budget of more than €25 million in 2014 and more than 280 employees, Fraunhofer FHR is one of the largest radar research institutes in Europe.

The most valued competencies of Fraunhofer FHR – numerical calculation of electromagnetic fields, high-frequency technology and sensor signal processing – enable the institute to design, develop and implement complex high-frequency systems, executing each step in-house. Fraunhofer FHR unite leading edge technology with sophisticated methods of signal processing to devise new types of system. This is accomplished by the interdisciplinary collaboration of physicists, engineers and mathematicians.

GLOBES Elektronik
Berliner Platz 12
74008 Heilbronn
www.globes.de

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.

IMST GmbH
Carl-Friedrich-Gauss-Str. 2-4
47475 Kamp-Lintfort
www.imst.com

IMST GmbH is a leading design house and development center for wireless communication systems, antennas, chip design and EDA software. An associated test center offers accredited test procedures as part of a development project or as separate service. IMST offers both standard products such as radio modules and modeling software as well as the development of complex systems and product design. Individualized support during every phase of product development including wireless technologies, from initial consulting to series production is one of the unique selling propositions of IMST.

Industrial Electronics GmbH
Rudolf-Diesel-Straße 2a
65719 Hofheim-Wallau
www.ie4u.de

Established as a Distribution company in Frankfurt/Main in 1963, Industrial Electronics GmbH focuses on components for RF/Microwave, EMC Interference Suppression, Fluid Metering and Acoustic applications.

Our corporate Head Office is located in 65719 Hofheim-Wallau since 2012.

Regarding RF and Microwave Technology, we offer high-end solutions for signal generation, signal conditioning and signal distribution. Furthermore our product spectrum includes amplifiers, antennas and antenna systems.

Industrial Electronics is your preferred partner for designing RF/Microwave hardware (subsystem) solutions and RF Test Systems for the qualification of active and passive components.

As our customer, you will receive high quality consulting support, tailored for your individual needs, as well as Engineering Services for customized solutions.

Industrial Electronics GmbH is a highly qualified, reliable and flexible partner for numerous industries such as Research and Development, industrial production and the Public Sector.

Intel Deutschland GmbH
Am Campeon 10-12
85579 Neubiberg
www.intel.com

You may know us for our processors. But we do so much more. Through computing innovation, we push the boundaries of smart and connected technology to make amazing experiences possible for every person on Earth. From powering the latest devices and the cloud you depend on, to driving policy, diversity, sustainability, and education, we create value for our stockholders, customers and society. The Internet of Things represents the next frontier of computing where delivering meaningful experiences and valued usages will require new approaches with high levels of integration, as well as genuine processor power.

Keysight Technologies
Herrenberger Straße 130
71034 Böblingen
www.keysight.com

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.

KROHNE Messtechnik GmbH
Ludwig-Krohne-Str. 5
47058 Duisburg
www.krohne.com

KROHNE is a world-leading manufacturer and supplier of solutions in industrial process instrumentation. KROHNE offers supporting products and services for one-stop-shopping and in industries as widespread as oil & gas, water & wastewater, chemical & petrochemical, food & beverage, power, minerals & mining and marine.

More than 400 engineers in the worldwide KROHNE Group are continuously engaged in research into promising technologies for the future, in pursuit of improved measurement and further developments. The family-owned enterprise have permanent representation in more than 130 countries and employ more than 3,500 people in order to bring highly innovative products from a single source, and tailor-made technical solutions to measurement requirements.

MiCIAN GmbH
Schlachte 21
28195 Bremen
www.mician.com

Mician is a leading developer of EM software tools for passive microwave components, horn antennas and feed networks. Mician's signature product µWave Wizard combines the flexibility of 2D/3D FEM with the speed and accuracy of traditional Mode Matching techniques. The benefit of using Mode Matching lies in its ability to perform and combine sub-circuit type full wave simulations, in conjunction with full parameterization of structural geometries for use with our built-in optimizers. The fast an easy composition of complex RF structures using basic building blocks eliminates the need for creating a full-up 3D model of the entire structure and speeds up the development process enormously, thereby significantly reducing cycle time. In addition to its fast and powerful numerical methods, µWave Wizard offers an appealing and ergonomic GUI that enables flexibility and openness including CAD export formats interfacing with most mechanical design tools.

Frequency Matters.

Microwave Journal
685 Canton Street
Norwood, MA 02062
www.mwjournal.com

Microwave Journal provides leading-edge technical content for RF, microwave and wireless engineers worldwide. MWJ the magazine reaches 50,000 qualified subscribers globally with practical design application articles for working engineers, the latest product features, news and analysis. MWJournal.com delivers the latest news, events, webinars, white papers, blogs, video and newsletters to RF/microwave professionals including focused areas such as the Aerospace & Defense channel. For 58 years, Microwave Journal has been THE resource for the engineers who are developing the latest technologies for the high frequency electronics sector.

REMCOM, Inc.
315 South Allen Street, Suite 416
State College, PA 16801
USA
www.remcom.com

REMCOM, market leader in FDTD-based modelling and simulation, provides innovative electromagnetic simulation software that simplifies the analysis of complex EM problems. Applications include cellphone antenna design, MRI coil analysis, radar, antenna placement on vehicles, ships and aircraft, as well as RFI propagation in the environment.

Rohde & Schwarz Vertriebs GmbH
Mühldorfstrasse 15
81671 München
www.rohde-schwarz.com

For more than 80 years, Rohde & Schwarz has stood for quality, precision and innovation in all fields of wireless communications. The company is strategically based on four pillars: test and measurement, broadcasting, secure communications, radiomonitoring and radiolocation. Thanks to this strategy the company can address diverse market segments, including wireless communications, the broadcasting and electronics industry, aerospace and defense, homeland security and critical infrastructures. The electronics group, headquartered in Munich (Germany), is among the world market leader in all of its business fields. Rohde & Schwarz is the world's leading manufacturer of wireless communications and EMC test and measurement equipment, as well as of broadcasting and T&M equipment for digital terrestrial television.

Rosenberger Hochfrequenztechnik GmbH & Co. KG
Hauptstraße 1
83413 Fridolfing
www.rosenberger.de

Rosenberger ranks today among the worldwide leading manufacturers 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 electronis, data systems, aerospace engineering. Founded in 1958, more than 6,200 Rosenberger employees are engaged in development, production and sale of products and services.

TACTRON ELEKTRONIK

TACTRON ELEKTRONIK GmbH & Co.KG
Bunsenstr. 5
82152 Martinsried / Planegg
www.tactron.de

TACTRON ELEKTRONIK was founded in 1984 and is focused on Sales & Consulting in the field of RF- and Microwave Technologies. We are representing leading companies with good international reputation in Germany, Austria and Switzerland.

Telecommunication, Space, Defence and Software are the main business areas of our company:

- Telecommunication: The focus in this business is the distribution of active and passive components as well as the modules, systems and equipment.
- Space: In cooperation with our principals we are offering HiRel components and systems.
- Defense: Many years of experience in the field of innovative signal processing for SIGINT- and EW-applications allows us to work closely with our customer to design systems for multi-spectral EW, ECM and Radar Target Simulation.
- Software: Tactron is a leading company in the field of Software tools for the RF- and Microwave industry. Already in 1984 Tactron was introducing the PC-based Software from EEsof in Germany, Austria and Switzerland.

Tactron is participating in large trade shows and exhibitions (such as electronica, EEEfCOM Workshop, EuMW) to stay in contact with our customers and also to add new customers.

Teledyne LeCroy GmbH
Im Breitspiel 11c
D-69126 Heidelberg
www.teledynelecroy.com

Teledyne LeCroy is a leading manufacturer of advanced test instruments that measure, analyze, and verify complex electronic signals. The Company offers high-performance real time oscilloscopes up to 100GHz bandwidth and protocol test solutions used by electronic design engineers in a wide range of application and end markets. Since our founding in 1964, we have focused on creating products that improve productivity by helping engineers resolve design issues faster and more effectively. Teledyne LeCroy is based in Chestnut Ridge, N.Y. For more information, visit Teledyne LeCroy's website at www.teledynelecroy.com.

Telemeter Electronic GmbH
Joseph-Gänsler-Straße 10
86609 Donauwörth
www.telemeter.info

Telemeter Electronic is a certified distribution and service company for manufactures of electronic and mechatronic products since 50 years. We put special emphasis on personalized, partner-like consulting and support. The company also offers devices, systems, detailed knowledge and many years of experience in diverse applications. Our technical divisions are Thermal Management, Industrial Components, Test &Measurement, RF & Microwaves, Aviation and Engineering & Service.