GEMIC 2025 German Microwave Conference Dresden

TECHNISCHE UNIVERSITÄT DRESDEN

Conference Program

March 17th - 19th
Dresden

Tomy Heyduck (DM-BY)

VDE ITG IEEE IMA e.V. EuMA

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HITECH RF & Microwave solutions

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VON ARDENNE

HENSOLDT Detect and Protect.

KROHNE

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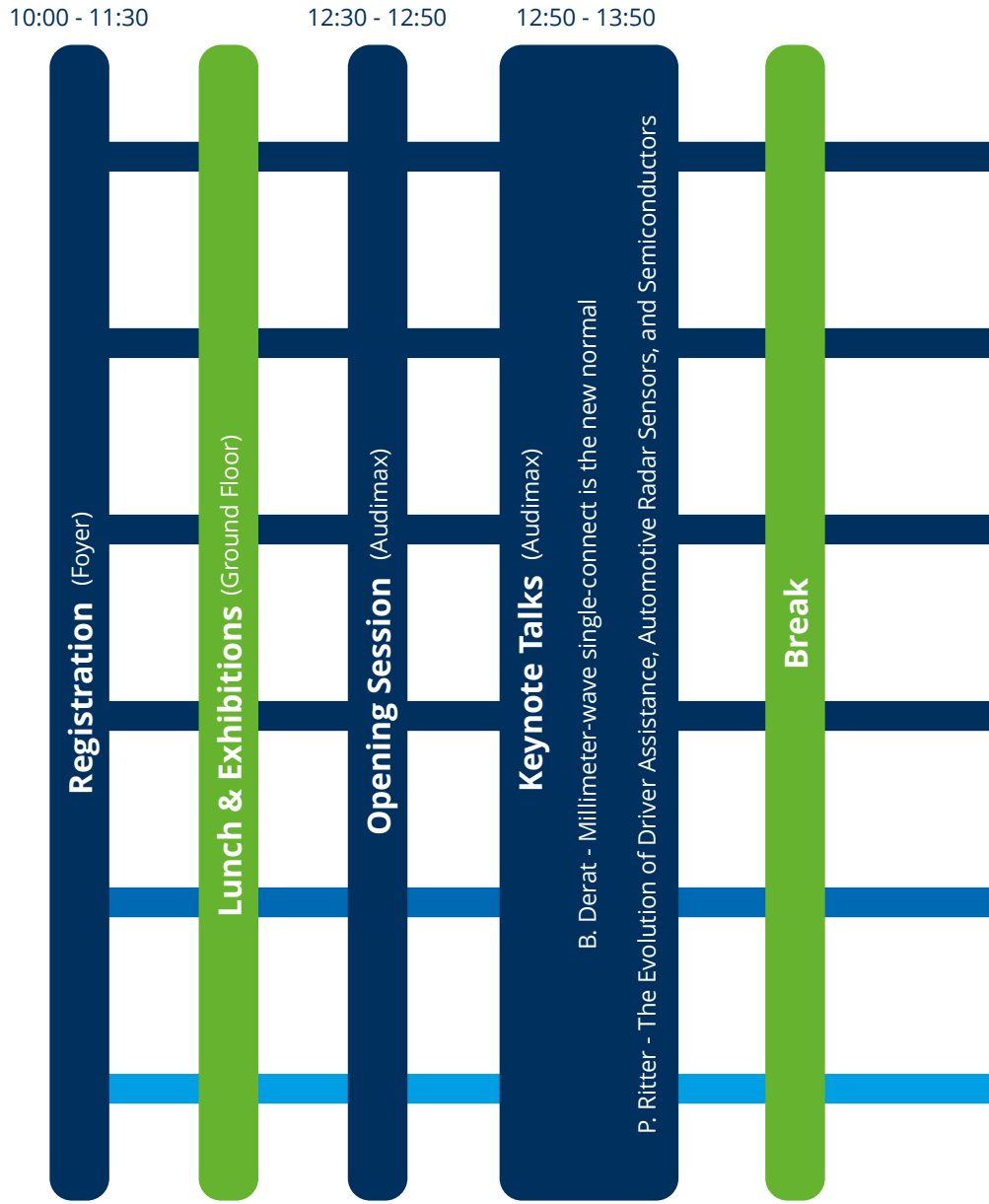
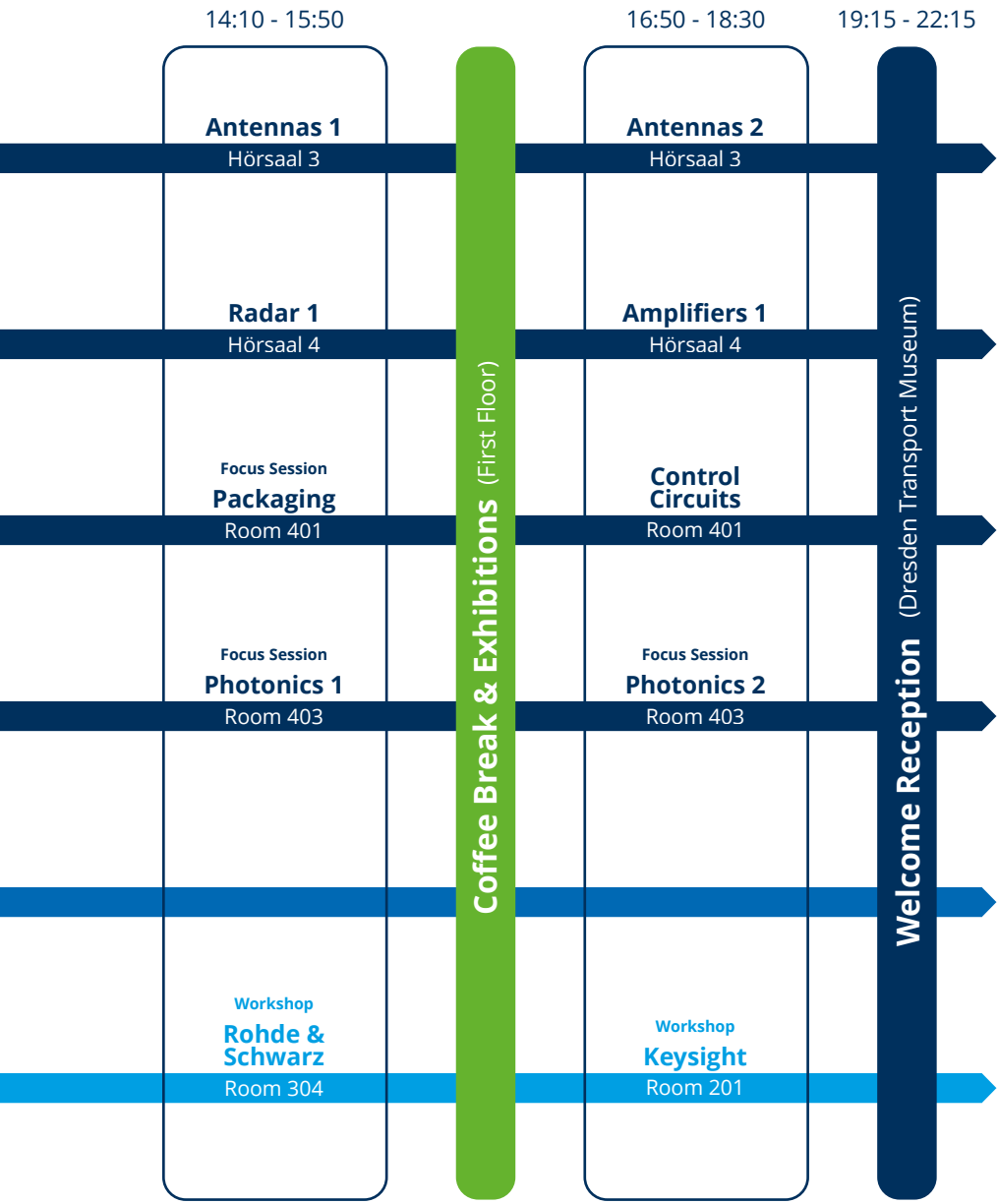
Program

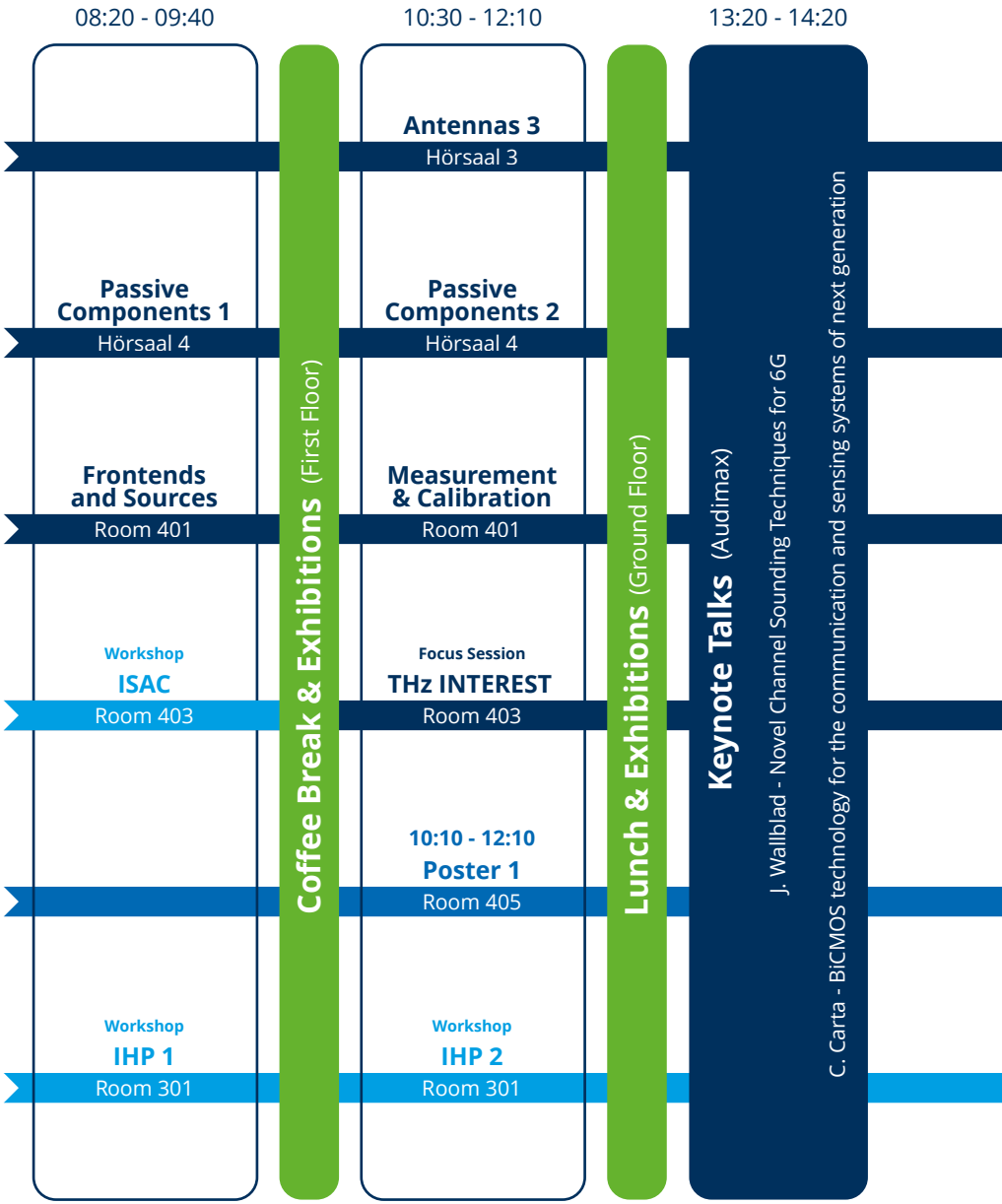
Monday, 17th of March 2025

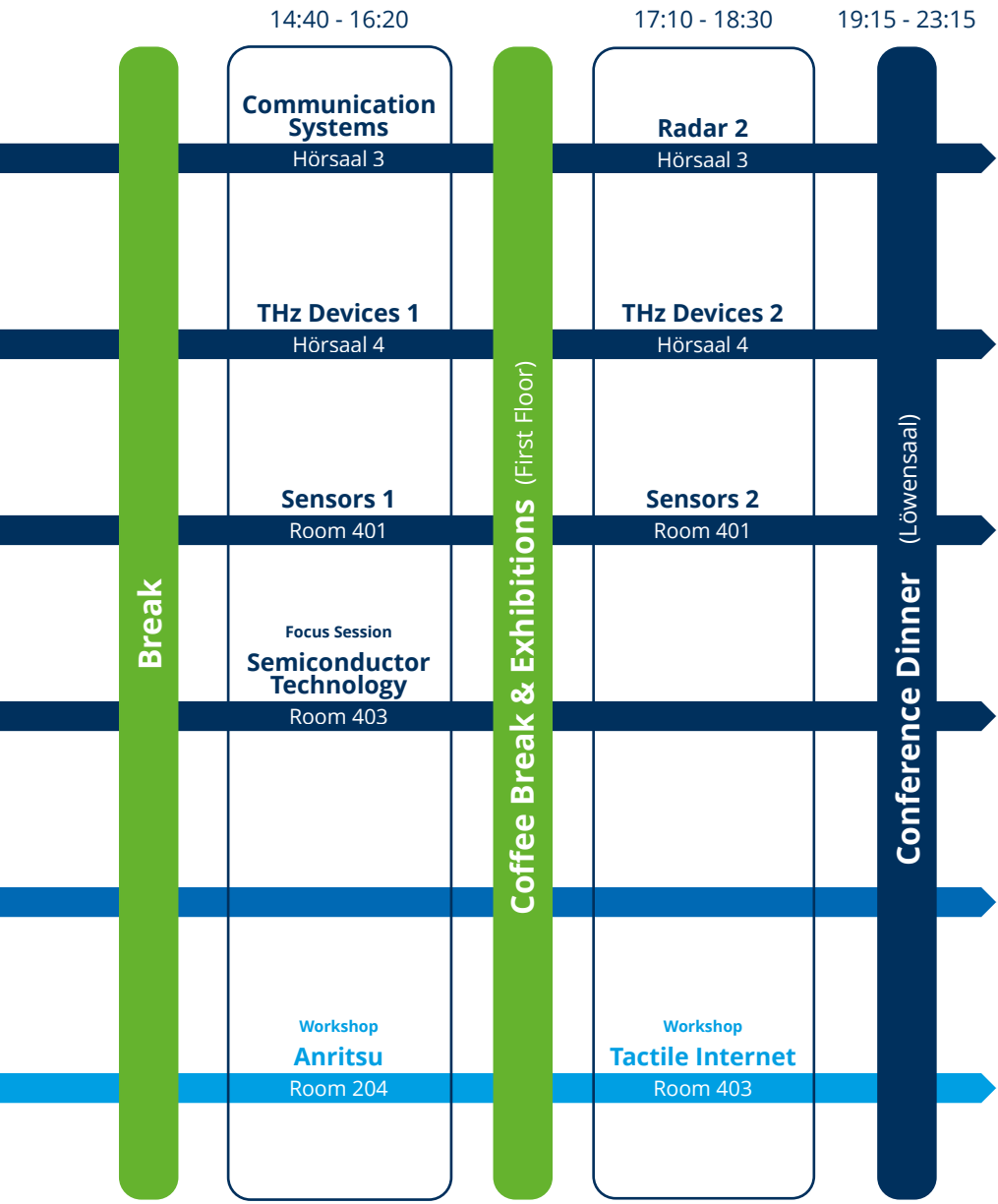



14:10 - 15:50
16:50 - 18:30
19:15 - 22:15
Antennas 1
Hörsaal 3
Antennas 2
Hörsaal 3
Radar 1
Hörsaal 4
Amplifiers 1
Hörsaal 4
Focus Session
Packaging
Room 401
Control Circuits
Room 401
Focus Session
Photonics 1
Room 403
Focus Session
Photonics 2
Room 403
Workshop
Rohde & Schwarz
Room 304
Workshop
Keysight
Room 201
Coffee Break & Exhibitions (First Floor)
Welcome Reception (Dresden Transport Museum)

Program

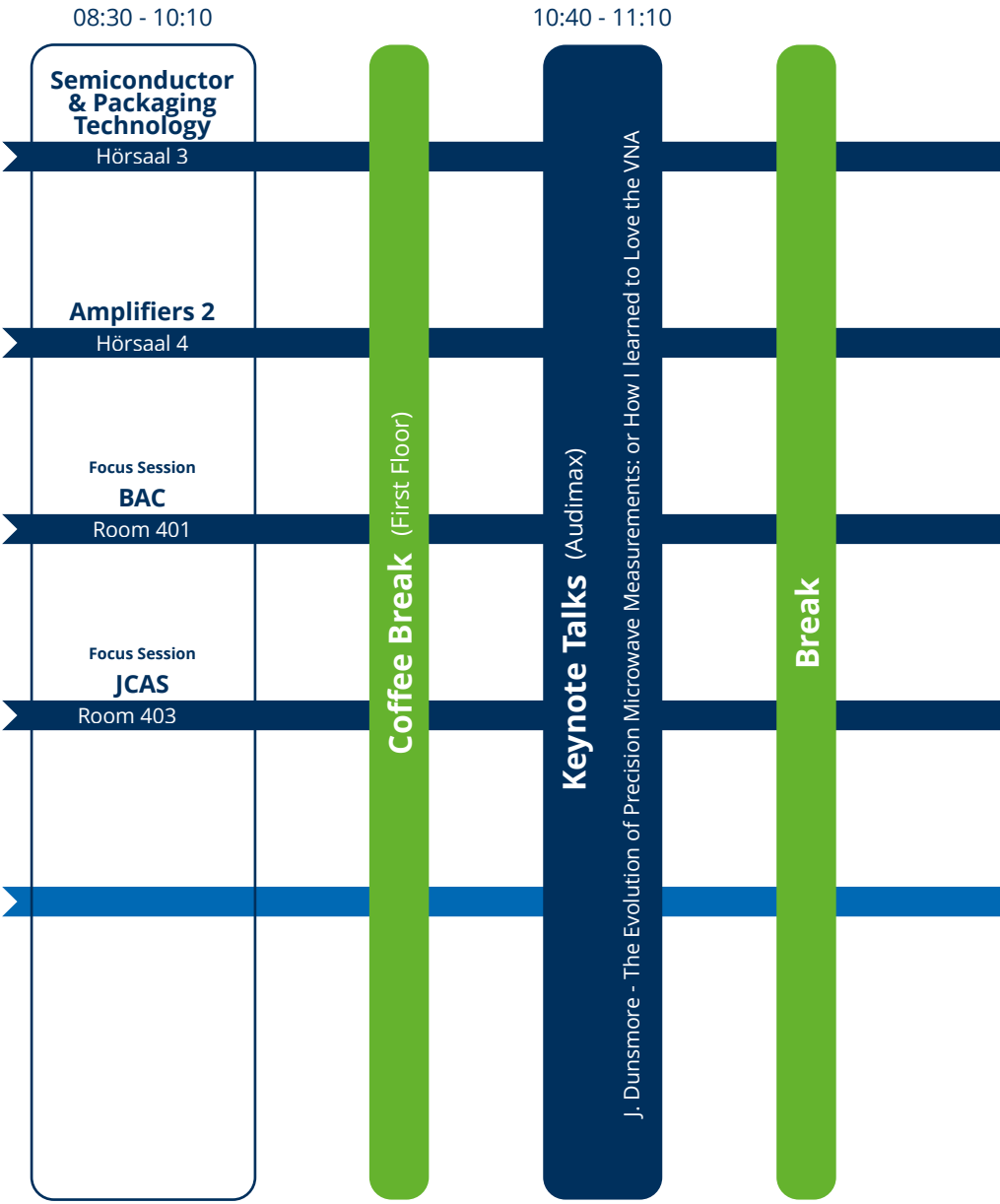
Tuesday, 18th of March 2025

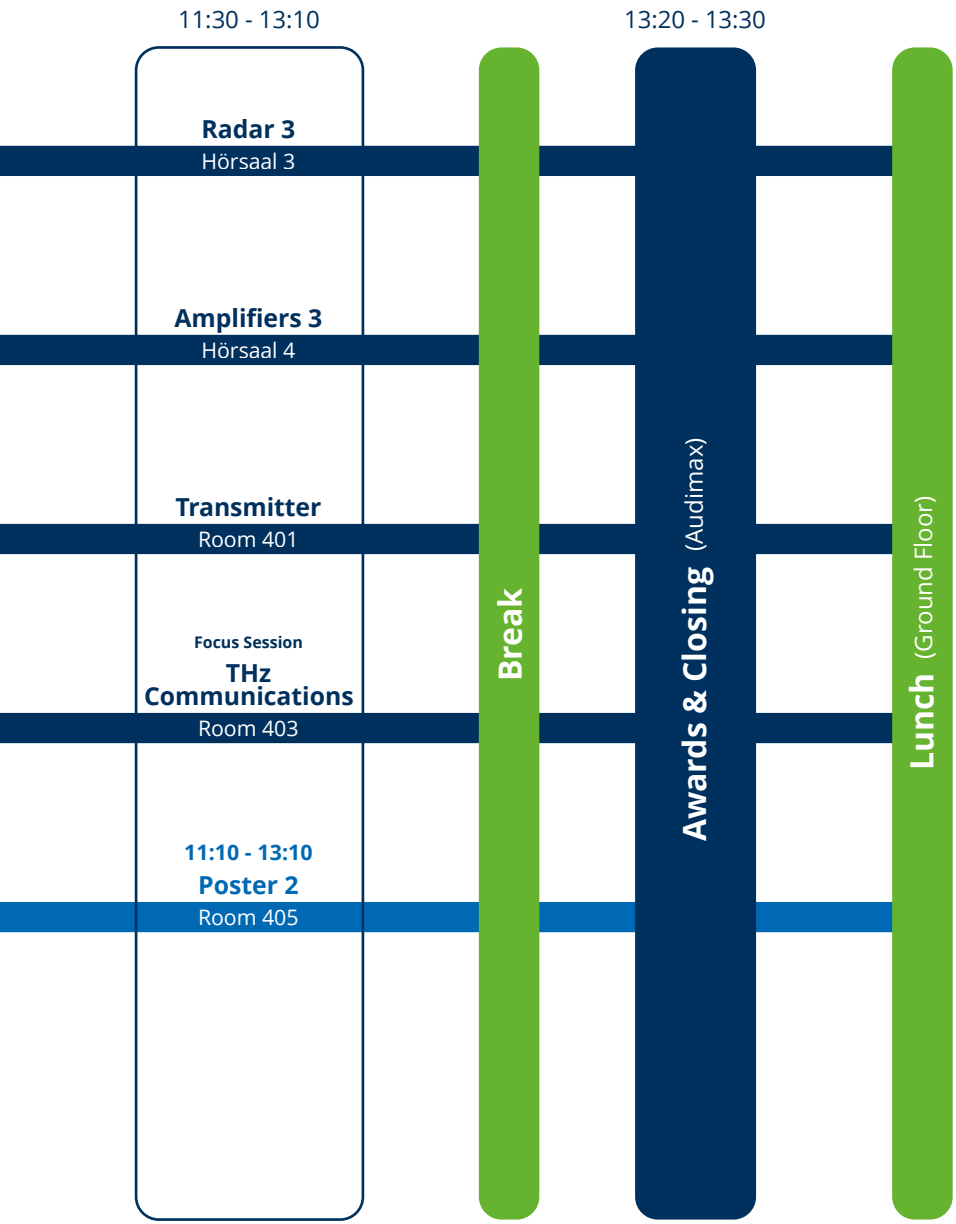



14:40 - 16:20
17:10 - 18:30
19:15 - 23:15
Break
Communication Systems
Hörsaal 3
Radar 2
Hörsaal 3
THz Devices 1
Hörsaal 4
THz Devices 2
Hörsaal 4
Sensors 1
Room 401
Sensors 2
Room 401
Coffee Break & Exhibitions (First Floor)
Conference Dinner (Löwensaal)
Focus Session
Semiconductor Technology
Room 403
Workshop
Anritsu
Room 204
Workshop
Tactile Internet
Room 403

Program

Wednesday, 19th of March 2025




11:30 - 13:10
13:20 - 13:30
Radar 3
Hörsaal 3
Amplifiers 3
Hörsaal 4
Transmitter
Room 401
Focus Session
THz Communications
Room 403
11:10 - 13:10
Poster 2
Room 405
Break
Awards & Closing (Audimax)
Lunch (Ground Floor)

Conference Location

Hörsaalzentrum (HSZ) of Technische Universität Dresden is located at **Bergstraße 64, 01069 Dresden**. It is easily accessible via public transportation. Please note that Hörsaalzentrum **cannot be reached by car**, as no parking spaces are available in the immediate vicinity. Visitors are therefore advised to use public transport.

Conference Venue


Nils Eisfeld

Public Transport:

From Dresden Main Station (Hauptbahnhof):

- **Tram:** line 3, direction "Coschütz" or line 8, direction "Südvorstadt" and alight at Nürnberger Platz
- 10-minute walk along Nürnberger Straße southeastwards
- **Bus:** line 66, direction "Freital-Deuben" or "Altkaitz" alight at Technische Universität (Fr.-Foerster-Platz)
- 2-minute walk

Main Station to Venue

STA Neustadt to Venue

From station Dresden-Neustadt:

- **Tram** line 3, direction "Coschütz" to Nürnberger Platz
- **S-Bahn**, line S1 "Schöna" or "Bad Schandau" or S-Bahn line S2 "Pirna" to Main Station ("Hauptbahnhof")


Crispen-Iven Mokry

The HSZ has seven floors, numbered from -2 to 4.
Events are organized in the south wing of the building and in the lecture halls as follows:

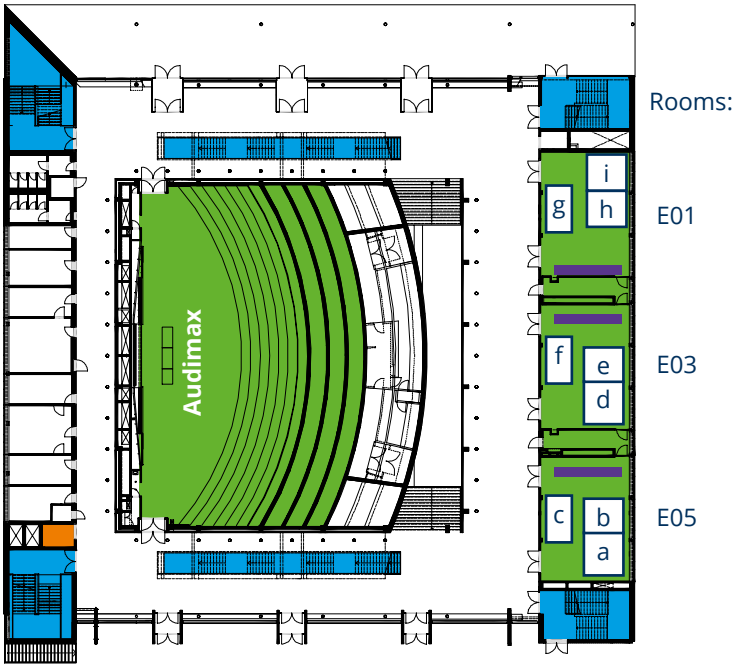
- Basement Floor (-1): Cloakroom & Registration (at the back of the lecture hall)
- Ground Floor (0): Sponsors & Lunch in rooms E01, E03 and E05
  Opening Session, Keynotes and Closing Session in the Audimax
- First Floor (1): Sponsors & Coffee in rooms 101, 103 and 105
- Second Floor (2): Workshops in room 201 and 204
- Third Floor (3): Workshops in rooms 301 and 304
  Sessions in lecture halls 3 and 4
- Fourth Floor (4): Sessions in rooms 401, 403, lecture halls 3 and 4
  Poster Sessions in room 405

Entrances to the front of Audimax can be found on floor 0 while the back is reachable from floor 1. The front of lecture halls 3 and 4 are accessible from floor 3. The back of lecture halls 3 and 4 are accessible from floor 4.

A barista can be found on Monday in room 101, on Tuesday in room 105 and on Wednesday in room E01.

Floor Plan, 0th Floor

Entrance from Street



Entrance from Lawn

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c	IHP
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i	Rohde & Schwarz

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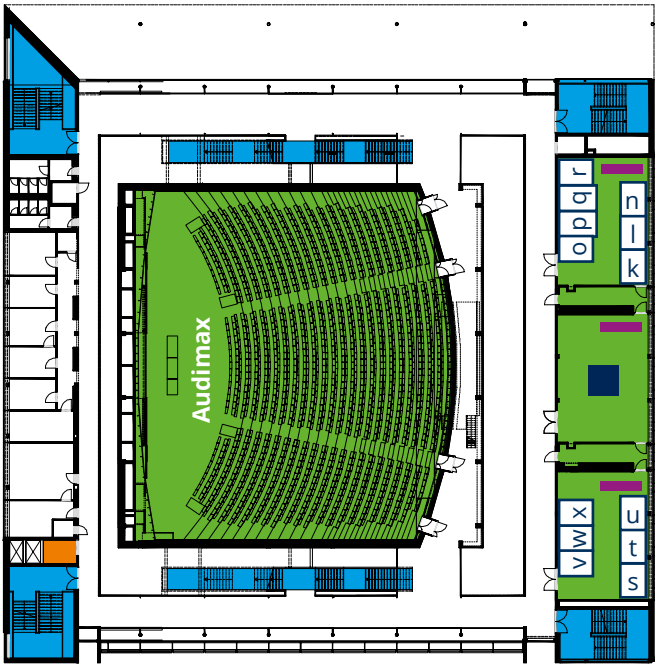
Elevator
Exhibition Rooms
Staircase
Lunch

Floor Plan, 1st Floor

Entrance from Street



Entrance from Lawn

Coffee **Student Corner (VDE)**

Bronze Sponsors

Room 101

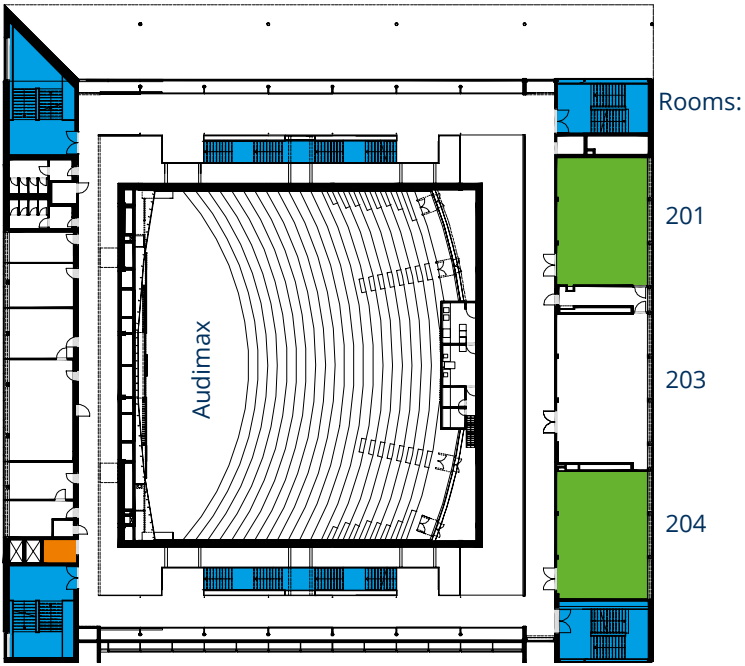
k	Telemeter Electronic
l	Milexia
n	Samtec
o	Hitech
p	Simuserv
q	Rosenberger
r	Krohne

Room 105

s	EMCO ELEKTRONIK
t	VON ARDENNE
u	contag
v	SPINNER
w	HENSOLDT
x	bsw
	TestSystems & Consulting

Floor Plan, 2nd Floor

Entrance from Street



Entrance from Lawn

Workshops

Room 201

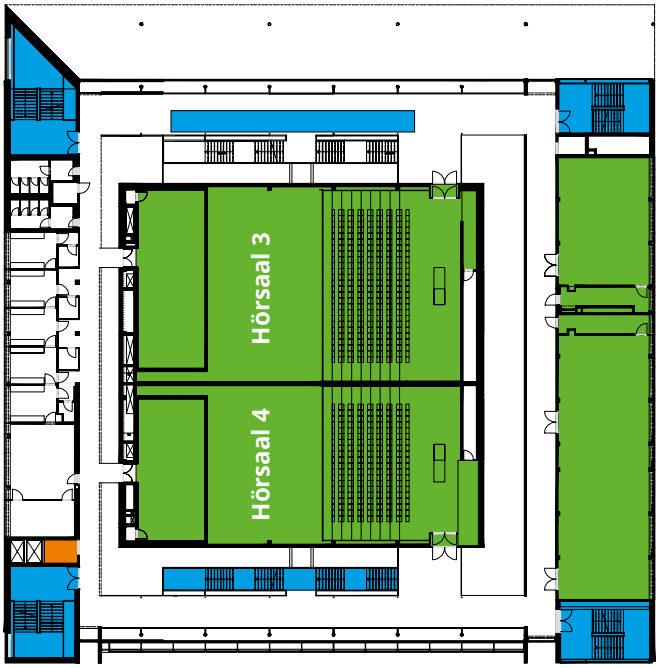
Monday: Keysight

Room 204

Tuesday: Anritsu

Floor Plan, 3rd Floor

Entrance from Street



Entrance from Lawn

Workshops

Room 301

Tuesday: IHP Solutions

Room 304

Monday: Rohde & Schwarz

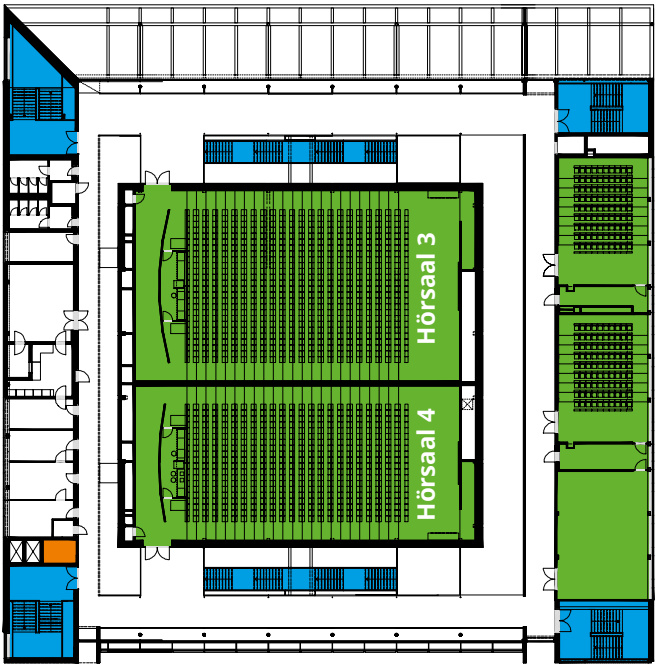
Sessions

Lecture Hall (Hörsaal) 3

Lecture Hall (Hörsaal) 4

Floor Plan, 4th Floor

Entrance from Street



Entrance from Lawn

Sessions

Room 401

Room 403

Lecture Hall (Hörsaal) 3

Lecture Hall (Hörsaal) 4

Poster Sessions

Room 405

Katrin Klunker

Welcome Message

Dear GeMiC 2025 participant,

It is our pleasure to welcome you to the 16th German Microwave Conference (GeMiC) in Dresden and to host this successful series of conferences in Saxony's capital from 17th to 19th of March 2025.

We are grateful for the support of

- German Institute for Microwave and Antennas Technologies (IMA)
- German Association for Electrical, Electronic & Information Technologies (VDE) and its Information Technology Society (ITG)
- Microwave Theory and Technology Society (MTT) of the IEEE and its German Section MTT/AP Joint Chapter
- European Microwave Association (EuMA)
- German Research Foundation (DFG)
- Dresden University of Technology (TUD)

GeMiC 2025 provides an excellent platform for the exchange of the latest research results and innovations in the field of microwave technology. Our programme is meticulously curated to ensure a rich and engaging experience. It includes exciting technical sessions and several hands-on workshops. We are thrilled to announce five keynotes that will delve into cutting-edge topics, including semiconductor technologies as well as characterisation capabilities and methods.

Monday

- **Benoit Derat** (Rohde & Schwarz GmbH)
- **Philipp Ritter** (Robert Bosch GmbH)

Tuesday

- **Johan Wallblad** (Anritsu EMEA GmbH)
- **Corrado Carta** (IHP Solutions GmbH)

Wednesday

- **Joel Dunsmore** (Keysight)

We will have four parallel tracks of technical papers, two poster sessions and six workshops from industry as well as academics. Moreover, at the large industry exhibition the latest measurement systems, semiconductor processes, software tools, electronics and packaging capabilities are presented. Lunch and coffee breaks will be provided in the exhibition rooms. We encourage you to use this time to network with exhibitors and see the latest advances in microwave technology and applications.

In addition to the scientific programme, we have prepared a number of networking opportunities for you.

On Monday, Welcome Reception will take place at Dresden Transport Museum close to Dresden's landmarks such as the Frauenkirche and Brühl's Terrace.

The conference dinner on the second day will be held in the stylish Löwensaal. Both events will provide an opportunity for informal exchanges in a pleasant atmosphere.

We would like to thank all authors, all reviewers, the award committee and all session chairs for their valuable contributions to GeMiC 2025.

We are very happy to announce that there will be two Best Paper Awards, kindly sponsored by IMA and EuMA:

- Best Conference Paper (IMA)
- Best Student Paper (EuMA)

We would like to express our sincere gratitude to our sponsors, without whose generous support GeMiC 2025 would not have been possible. Their commitment to the advancement of microwave technology and the promotion of scientific exchange is truly commendable.

- Gold Sponsors: Rohde & Schwarz, Anritsu, IHP Solutions, BOSCH, Keysight, Joynext
- Silber Sponsors: FormFactor, MPI, ACST
- Bronze Sponsors: Rosenberger, bsw TestSystems&Consulting, Telemeter Electronic, EMCO Elektronik GmbH, SIMUSERV, SPINNER, HITECH RF & Microwave Solutions, NI, Contag, Von Ardenne, Hensoldt, Krohne, Milexia, Samtec

We would like to thank the German Research Foundation (DFG) for funding the conference and supporting our international guests.

The GeMiC 2025 organizing team wishes you a successful and enlightening conference with many interesting conversations, new impulses for your work and lasting impressions of the beautiful city of Dresden.

Committees and Boards

Conference Team

Dirk Plettemeier, Frank Ellinger, Gerhard Fettweis

General Chair

Dirk Plettemeier

Technical Program Chair

Dirk Plettemeier

Publication Chair

Bernhard Klein

Head of Prize Committees

Kambiz Jamshidi

Conference Organization

Bernhard Klein, Wolf-Stefan Benedix, Ronny Hahnel, Angela Schober, Florian Grabs, Marco Mütze, Sebastian Hegler, Maximilian Hermsdorf, Abdul Quddious

VDE Team

Annelie Oleniczak, Nicolas Parisel, Damian Dudek

Review Board

Muhammad Sajjad Ahmad, Robin Augustine, Jan Balzer, Niels Benson, Manfred Berroth, Josef Boeck, Christian Bornkessel, Corrado Carta, Andreas Czylwik, Mark Eberspächer, Thomas F. Eibert, Frank Ellinger, Daniel Erni, Gerhard Fettweis, Thomas Fickenscher, Georg Fischer, Norman Franchi, Markus Gardill, Matthias Geissler, Friedel Gerfers, Janusz Grzyb, Amelie Hagelauer, Armen Harutyunyan, Dirk Heberling, Matthias A. Hein, Stefan Heinen, Wolfgang Heinrich, Jan Hesselbarth, Michael Höft, Vadim Issakov, Arne F. Jacob, Kambiz Jamshidi, John Jelonnek, Thomas Kaiser, Ingmar Kallfass, Wilhelm Keusgen, Dietmar Kissinger, Peter Knott, Alexander Kölpin, Marco Krondorf, Andreas Mai, Holger Maune, Alberto Moreira, Thomas Musch, Ivan Ndip, Renato Negra, Giang Nguyen, Krzysztof Nieweglowski, Ullrich R. Pfeiffer, Dirk Plettemeier, Nils Pohl, Sascha Preu, Rüdiger Quay, Pramod Rangaiah, Ilona Rolfes, Matthias Rudolph, Patrick Scheele, Lorenz-Peter Schmidt, Martin Schneider, Thomas Schneider, Hermann Schumacher, Ahmet Çağri Ulusoy, Thomas Ußmüller, Martin Vossiek, Christian Waldschmidt, Jianqing Wang, Tobias Weber, Nils Weimann, Anne Wolf, Thomas Zwick

General Information

Wi-Fi

Personal Wi-Fi access credentials can be found in the conference bag. Additionally, eduroam is available in the HSZ.

Poster Session

All posters will be displayed from Tuesday in the morning, 9 AM until the end of the conference.

DVB Tickets

All venues and also the airport are within DVB ticket zone 1.

If you do not have a Deutschlandticket, we recommend purchasing a day ticket, as at least three journeys are required per day. Please buy the ticket before using public transportation. It is not always possible to buy tickets on board. You also have to stamp your ticket before using it.

We recommend using the DB app for online tickets. Therefore open your DB navigator, scroll down to "Tickets & offers" / "Tickets & Angebote". Then scroll to the last entry on the right called "Transport association tickets" / "Verbundtickets" and click on it. Now you can select regional public transport associations. Select "Dresden & Umland" and afterwards click on "Go to ticket selection" / "Zur Ticketauswahl". Select the ticket you want to buy. As tariff zone select "Dresden". This zone includes all conference venues as well as the airport.

In Dresden you can also use every regional train (i.e., no IC/ICE, EC) to "Hauptbahnhof" with a valid DVB ticket.

Cloakroom

There is a free cloakroom in all venues. No liability is accepted for valuables. You may also temporarily place your luggage here.

Photos

Please note that photos will be taken during the event. The photos will be made available to you password-protected after the conference.

Taxi

Call +49 351 211211 for taxi.

Welcome Reception

The **Dresden Transport Museum** is located at **Augustusstraße 1, 01067 Dresden**. It is easily accessible via public transportation. Please note that the Dresden Transport Museum **cannot be reached by car**, as no parking spaces are available in the immediate vicinity. Visitors are therefore advised to use public transport.

GMaps Welcome Reception

Michael R. Hennig (DML-BY)

Public Transport

From Technische Universität (Fr.-Foerster-Platz)

- Bus: line 66, direction "Lockwitz" or "Nickern", at Main Station ("Hauptbahnhof") switch to tram line 3, direction "Wilder Mann" or tram line 7, direction "Weixdorf" and alight at station "Theaterplatz"

From station Nürnberger Platz

- 10-minute walk along Nürnberger Straße northwestwards to station "Nürnberger Platz" and proceed as follows
- Tram: line 3, direction "Wilder Mann" alight at "Theaterplatz"

Venue to Museum

From station "Theaterplatz" walk past the cathedral "Dresdener Hofkirche" and follow the "Procession of Princes". The venue is now on your right.

Conference Dinner

The Conference Dinner will take place in the unique venue **Löwensaal** that is located at **Dr.-Külz-Ring 10, 01067 Dresden**. It is easily accessible via public transportation. Please note that the Löwensaal **cannot be reached by car**, as no parking spaces are available in the immediate vicinity. Visitors are therefore advised to use public transport.

GMaps Dinner

Public Transport

From Technische Universität (Fr.-Foerster-Platz)

- Bus: line 66, direction "Lockwitz" or "Nickern", at Main Station ("Hauptbahnhof") switch to tram line 3, direction "Wilder Mann" or tram line 7, direction "Weixdorf" and alight at station "Prager Straße"

From station Nürnberger Platz

- 10-minute walk along Nürnberger Straße northwestwards to station "Nürnberger Platz" and proceed as follows
- Tram: line 3, direction "Wilder Mann" alight at "Prager Straße"

Venue to Löwensaal

From station "Prager Straße" walk past Thalia on the right. The Löwensaal is located in the building complex directly behind Thalia book store.

Keynote Talks

Johan Wallblad

Field Application Engineer uW&RF, Anritsu

Johan has worked as an RF and microwave engineer for close to twenty years. It all started at Ericsson, responsible for the Bluetooth hardware reference design in Mobile Platforms, and then onwards to digital radio ASIC development for base stations. After that, Johan continued as Field Applications Engineer. First at Marvell Semiconductor, focusing on WLAN chipsets, and since 2015 at Anritsu as product specialist, focusing on spectrum and network analysis (VNA).

Benoit Derat

Senior Director for Systems Developments and Project Implementations, Rohde & Schwarz, Munich

Benoit Derat received the Engineering degree from SUPELEC, in 2002, and the Ph.D. degree (Hons.) in physics from the University of Paris XI, in 2006. From 2002 to 2008, he worked at SAGEM Mobiles, as an Antenna Design and Electromagnetics Research Engineer. In 2009, he founded ART-Fi, which created the first vector-array specific absorption rate measurement system. He operated as the CEO and the President of ART-Fi, before joining Rohde & Schwarz, Munich, in 2017. He is currently the Senior Director of Engineering for Vector Network Analyzers, Electromagnetic Compatibility, Over-The-Air and Antenna Test applications. Dr. Derat is a Senior Member of the Antenna Measurement Techniques Association (AMTA) and a Distinguished Lecturer of the IEEE EMC Society (2024 – 2025). He is the author of more than 80 scientific journals and conference papers, and an inventor on more than 40 patents, with main focus in antenna systems near and far-field characterization techniques.

Philipp Ritter

graduated in Computer and Communications Engineering in 2008, and received the Ph.D. degree in Electronics Engineering in 2013. He held positions at STMicroelectronics as a high-speed data converter design engineer, at Continental Automotive GmbH as a high-frequency specialist and at Robert Bosch GmbH as a millimeter-wave radar design engineer. He is now product manager for the Bosch radar semiconductor portfolio.

Joel Dunsmore

is a Keysight R&D Fellow working at the Santa Rosa Site. He graduated with a BSEE (1982) and MSEE (1983) from Oregon State University. He received his Ph.D. from Leeds University in 2004 focusing on the Fourier Transform with Applications to Filter Tuning. He started in 1983 full time for Hewlett-Packard as a designer for microwave components such as mixers, filters and amplifiers. His experience and frustration testing these directly led to development of some of the advanced Vector Network Analyzer (VNA) capabilities we have today. He was a principal contributor to PNA family of network analyzers, with recent work in non-linear test, including differential devices, and mixer measurements, as well as modulated and spectrum measurements. He has received 36 patents and authored the “Handbook of Microwave Component Measurements, 2nd Edition (John Wiley, 2020)”. He was selected in 2025 as a Distinguished Microwave Lecturer (DML) for IEEE MTT-S. His YouTube Channel is @DrJoelVNA.

Keynote Talks

Corrado Carta

was born in Cagliari, Italy. He received the master's degree in electrical engineering from the University of Cagliari, Italy, in 2000, and the Ph.D. degree from the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland, in 2006.

From July 2000 to February 2006, he was with the Microwave Electronics Group at ETH Zurich, where his main research interests were in the field of silicon radio frequency integrated circuit (RFIC) design for microwave wireless communications. From April 2006 to May 2008, he was with the High-Speed Electronics Group, Department of Electrical and Computer Engineering, University of California at Santa Barbara, CA, USA, where his research work focused on the design of silicon integrated circuits for very large mm-wave phased arrays. In June 2008, he joined Sonos, Inc., Santa Barbara, where he led the RF Engineering and Compliance Team, involved in the development and characterization of the wireless interface of new and existing products. In March 2010, he joined the Chair of Circuit Design and Network Theory, Technische Universität Dresden, Germany, where he lead the mm-Wave IC Design Group and the Beyond-Moore Electronics Group. Since September 2022 he is a Professor at the Technische Universität Berlin, chair of Broadband and High-Frequency Integrated Circuits, with a joint appointment as Head of the Circuit-Design Department of IHP Microelectronics, Frankfurt (Oder), Germany, conducting research on a wide range of topics, including integrated microwave and millimeter-wave circuits, broadband mixed-signal circuits and high-efficiency circuits for communication and sensor applications.

Gold Sponsors

ROHDE&SCHWARZ
Make ideas real

Rohde & Schwarz is striving for a safer and connected world with its Test & Measurement, Technology Systems and Networks & Cybersecurity Divisions. For 90 years, the global technology group has pushed technical boundaries with developments in cutting-edge technologies. The company's leading-edge products and solutions empower industrial, regulatory and government customers to attain technological and digital sovereignty. The privately owned, Munich based company can act independently, long-term and sustainably. Rohde & Schwarz generated net revenue of EUR 2.78 billion in the 2022/2023 fiscal year (July to June). On June 30, 2023, Rohde & Schwarz had around 13,800 employees worldwide.

Anritsu

Anritsu Corporation has been a provider of innovative communications solutions for 125 years. The world leading test and measurement solutions include wireless, optical, microwave/RF and digital instruments, and monitoring systems, that can be used during R&D, manufacturing, installation, and maintenance of telecommunication networks. Anritsu supplies a wide range of leading-edge RF and Microwave test solutions operating at frequencies up to 750 GHz. Product lines include Vector Network Analyzers, Spectrum Analyzers, Signal Generators, Power Meters, including benchtop and handheld units. The company develops advanced solutions for 5G, M2M, IoT, as well as other emerging and legacy wireline and wireless communication markets.

solutions

IHP Solutions GmbH connects cutting-edge research with industry by transferring technologies, products, and IP from the Leibniz Institute for High Performance Microelectronics (IHP). Founded in 2015, the company specializes in SiGe BiCMOS technology, offering foundry services for ASICs, including multi-project wafers (MPW), engineering, and low-volume production runs, along with packaging, measurement, and testing. Additionally, IHP Solutions provides access to IHP's IP and patents, supported by a robust Quality Management System to ensure excellence in delivering silicon-based solutions and technology transfers.

Gold Sponsors

The Bosch Group is a leading global supplier of technology and services. It employs roughly 429,000 associates worldwide (as of December 31, 2023). The company generated sales of 91.6 billion euros in 2023. Its operations are divided into four business sectors: Mobility, Industrial Technology, Consumer Goods, and Energy and Building Technology. With its business activities, the company aims to use technology to help shape universal trends such as automation, electrification, digitalization, connectivity, and an orientation to sustainability. In this context, Bosch's broad diversification across regions and industries strengthens its innovativeness and robustness. Bosch uses its proven expertise in sensor technology, software, and services to offer customers cross-domain solutions from a single source. It also applies its expertise in connectivity and artificial intelligence in order to develop and manufacture user-friendly, sustainable products. With technology that is "Invented for life," Bosch wants to help improve quality of life and conserve natural resources. The Bosch Group comprises Robert Bosch GmbH and its roughly 470 subsidiary and regional companies in over 60 countries. Including sales and service partners, Bosch's global manufacturing, engineering, and sales network covers nearly every country in the world. Bosch's innovative strength is key to the company's further development. At 136 locations across the globe, Bosch employs some 90,000 associates in research and development, of which nearly 48,000 are software engineers.

The Mobility Electronics (ME) business sector is an internal production and development service provider for electronic control units and semiconductors (integrated circuits and sensors) as well as a manufacturer of semiconductor products and sensors for the external market. The semiconductor product spectrum for automotive applications ranges from application-specific ICs and power semiconductors to micro-electro-mechanical sensors.

KEYSIGHT TECHNOLOGIES

Keysight Technologies is a global technology leader in electronic test and measurement, with a presence in more than 100 countries. Keysight's solutions optimize networks and help bring electronic products to market faster and more cost-effectively — from design simulation, prototype validation, to manufacturing test, optimization in networks and cloud environments. We work with our customers on next-generation technologies in 5G, automotive, Internet of Things (IoT) and data center infrastructure. In the 2020 financial year, Keysight achieved revenues of $4.2 billion.

Keysight in Germany

In Germany, the company employs around 715 people, most of them in Böblingen. At the headquarters in Böblingen, founded in 1959 as the first Hewlett-Packard plant in Europe, test solutions are developed and marketed for the automotive market, optical network expansion and data centres. Keysight's test solutions are among the world's leading test and measurement products. More information about Keysight is available at www.keysight.com and on Facebook, LinkedIn, Twitter and YouTube.

Gold Sponsors

JOYNEXT – WE CONNECT FUTURE

JOYNEXT is a leading AutoTech company, the Automotive Connectivity Business Unit of Joyson Electronics. Headquarters in China, JOYNEXT marks our global presence in Germany, Poland, France, US, Japan, etc. We develop technologies for intelligent connected vehicles and provide a highly personalized mobility experience that is empathic, safe, and adaptable. Our 1,500+ employees work at 7 R&D centers, 3 global manufacturing locations, and 4 customer centers around the world.

For more than two decades, JOYNEXT has been working as the development partner and system supplier of renowned car manufacturers and established long-term partnerships with various well-known OEMs. Putting ourselves in the shoes of users, we are consistently working on intelligent cockpit, smart connectivity, autonomous driving, and software solutions & services for both, carmakers and users, offering them a personalized mobility experience.

JOYNEXT is accelerating the shift to smart mobility with our integrated hardware and software solutions. Our intelligent cockpit and smart connectivity products are equipped in millions of vehicles worldwide, complemented by our capabilities in developing autonomous driving technologies and software products, which lay a solid foundation for the cockpit and driving fusion facing the era of Central Computing Units.

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- Antenna measurement solutions
- RF-absorber
- Fully customized solutions
- RF-components
- VNA
- Oscilloscopes
- EMF measurement solutions

Application fields

- RF & EMI testing
- Radar test solutions
- Test & Measurement
- Forensic solutions
- Reverberation chambers
- Supply of RF components & sub-systems

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is an independent German technology company founded in 1991 for applied measurement and testing technology as well as for components in the areas of EMC, high frequency technology, microwave technology and avionics.

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- 5G components
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VON ARDENNE develops and manufactures systems for the industrial vacuum coating of materials such as glass, wafers, metal strips or polymer films.

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HENSOLDT is a leading company in the European defence industry with a global reach. Based in Taufkirchen near Munich, the company develops sensor solutions for defence and security applications. As a system integrator, HENSOLDT offers platform-independent, networked sensors. At the same time, the company is driving forward the development of defence electronics and optronics as a technology leader and investing in new solutions based on software-defined defence. In addition, the company is expanding its range of offers to include new service models and is extending its portfolio of system solutions. In 2023, HENSOLDT achieved a turnover of 1.85 billion euros. Following the acquisition of ESG GmbH, the company employs around 8,000 people. HENSOLDT is listed on the Frankfurt Stock Exchange in the MDAX.

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Monday, 17th of March

10:00 - 11:30	**Registration**	Foyer
11:30 - 12:30	**Lunch**	E01, E03, E05
12:30 - 12:50	**Opening**	Audimax
12:50 - 13:20	**Keynote 1: Benoit Derat**	Audimax
13:20 - 13:50	**Keynote 2: Philipp Ritter**	Audimax
13:50 - 14:10	**Break**	
14:10 - 15:50	**Antennas 1**	Hörsaal 3
14:10 - 15:50	**Focus Session Packaging**	Room 401
14:10 - 15:50	**Focus Session Photonics 1**	Room 403
14:10 - 15:50	**Radar 1**	Hörsaal 4
14:10 - 15:50	**Workshop Rohde&Schwarz**	Room 304
15:50 - 16:50	**Coffee Break**	101, 103, 105
16:50 - 18:30	**Amplifiers 1**	Hörsaal 4
16:50 - 18:30	**Antennas 2**	Hörsaal 3
16:50 - 18:30	**Control Circuits**	Room 401
16:50 - 18:30	**Focus Session Photonics 2**	Room 403
16:50 - 18:30	**Workshop Keysight**	Room 201
19:15 - 22:15	**Welcome Reception**	Transport Museum

Registration	**10:00 - 11:30** **Foyer**
Lunch	**11:30 - 12:30** **Rooms E01, E03, E05**
Opening	**12:30 - 12:50** **Audimax**
Keynote 1	**12:50 - 13:20** **Audimax** **Dirk Plettemeier**

12:50
Audimax

Rohde & Schwarz: Millimeter-wave single-connect is the new normal

Benoit Derat

In 1950, Rohde & Schwarz achieved a remarkable milestone and created the first ever vector network analyzer. What was back then a breakthrough in radiofrequency measurements was an instrument capable of single-port S-parameter characterization up to 300 MHz. 75 years and a humongous amount of technology leaps later with current strong drive from AI and high-speed digital, RF design and testing have evolved to a point where characterization up to 67 GHz and beyond is the new normal. One measurement box is also expected to capture much more than S-parameters and provide a complete performance overview of the device under test after one single calibration and one connection to the DUT. This keynote aims at proposing a view of the latest market trends and evolutions which are driving challenges and major evolutions of measurement instrumentation, with a particular focus on the latest innovation and advances in VNA technology and an outlook towards the future.

13:20 - 13:50
Audimax
Frank Ellinger

Keynote 2

13:20 BOSCH: The Evolution of Driver Assistance, Automotive Radar Sensors, and Semiconductors

Audimax

Philipp Ritter

This talk will explore the transformative evolution of Advanced Driver Assistance Systems (ADAS), with a particular focus on radar sensor innovations and semiconductor technologies. As the automotive industry shifts towards enhanced safety and automation, we will address the critical role of radar sensors in ensuring comfort, reliability, and accountability across diverse vehicle architectures. Key topics will highlight the advancements in both conventional and AI-driven signal processing, alongside the development of a cost-efficient Radar System-On-Chips (SoC) to meet the growing demands of the market with various levels of automation from Level 0 to Level 2+. The presentation will include insights into design challenges, performance metrics, and field demonstrations, showcasing today's SoC capabilities, e.g. in mitigating interference and enhancing target detection. By integrating advanced semiconductor solutions with system-level considerations, this talk will provide a comprehensive overview of the future landscape of automotive radar technology and its implications for the industry.

13:50 - 14:10

Break

Antennas 1

14:10 - 15:50
Hörsaal 3
Thomas Fickenscher

14:10 Dielectric Superstrate Structures for Gain Enhancement of a Patch Antenna in the Ku-band

Hörsaal 3

Roslin Francis
Robert Bosch GmbH, Germany

Low-earth orbit (LEO) satellites are emerging as an alternate technology to facilitate seamless internet connectivity in automotive applications and overcome the current limitations of terrestrial cellular networks. However LEO satellite connectivity demands the use of high gain antenna arrays which due to a large size is a challenge to integrate into the roof of a car. A compact design is thus essential which can be achieved using individual antenna elements with higher gain per unit area. In this paper a novel low-profile and compact single antenna element with dielectric ring as a replacement of a dielectric slab superstrate is presented. Despite a small additional volume due to the superstrate, it offers a gain enhancement of 3 dB over a conventional patch antenna. A 3 dB improvement in gain means the total number of antenna elements can be reduced by half resulting in a reduced overall size. With a footprint of 0.25 λ_0^2 and height of 0.5λ_0 where λ_0 corresponds to the free-space wavelength, this design is promising for implementation in an array configuration owing to reduction in material, weight and cost.

14:30 Wideband Aperture Coupled Patch Antenna for 6G Millimeter-Wave Applications

Hörsaal 3

Caroline Sebastian; Samira Faghih-Naini; Torsten Reißland; Robert Weigel; Norman Franchi; Benedict Scheiner

Lehrstuhl für Intelligente Technische Elektronik und Systeme, Friedrich-Alexander-Universität Erlangen-Nürnberg

This paper presents a wideband stacked aperture coupled microstrip patch antenna for 6G mmWave applications. The wide bandwidth behavior is obtained by employing two closely spaced coupled reso-

nances in a multi layered structure. The antenna characteristics that lead to a coupled resonance are achieved by an aperture coupled feed, stacking up of parasitic patches vertically and an H shaped radiating patch. An antenna is fabricated, and measurements are compared with simulations. The measurement result shows that the antenna has a wide relative bandwidth of 15% at operational frequency range of 25.21 GHz to 29.3 GHz, which agrees with the simulated bandwidth, taking the manufacturing tolerances into account. The measured antenna gain mostly agrees with the simulated gain.

14:50 Compact Broadband 27 GHz Aperture-Coupled Stacked Patch MIMO Antenna Array

Hörsaal 3

Benjamin Nuss; Linus Hampel; Thomas Zwick
Karlsruhe Institute of Technology

To enable testing of new waveforms and algorithms for future joint communication and sensing (JCAS) and radar applications, powerful and flexible multiple-input multiple-output (MIMO) testbeds are required. In the German research project Open6GHub, such a broadband massive MIMO testbed is being set up, which provides an extremely high number of channels in the frequency range from 24 GHz to 30 GHz. Therefore, very broadband antennas in the millimeter wave range are needed that can flexibly be used to design a variety of antenna arrays. The element design presented in this paper offers the required bandwidth of 6 GHz at a center frequency of 27 GHz with a small element size in the range of half the free-space wavelength. Based on this single element, an exemplary compact 8x8 antenna array was developed and measured.

15:10 A Modular and Scalable System Concept for Phased Array Antennas in Satellite Constellations

Hörsaal 3

Dominik Starzmann[1]; Christian Arnold[1]; Sabine Klinkner[2]
[1] Tesat–Spacecom GmbH & Co. KG; [2] University of Stuttgart

Phased array antennas play an increasing role in everyday life. They are a key technology to increase the network capabilities of 5G and 6G and are becoming a crucial component of satellite communication. In space, they are deployed in different orbits for various use ca-

ses which results in a wide performance range and requires a variety of antenna designs. Hence, a modular and scalable approach for a phased array antenna is presented to tackle the problem of designing various antennas to serve different orbits and missions. The Ethernet Antenna is a phased array antenna with 64 elements which is a modular building block for larger arrays. The necessary performance per use case is met by using an appropriate number of building blocks and by selecting the proper modules which requires only limited effort for redesign. This paper demonstrates that this approach results in an antenna design that meets the requirements of various orbits and use cases while coping with different satellite platforms.

15:30 Electrically Small Super-Directive Microstrip Patch Antenna Covered by Hemispherical Magnetodielectric Material

Hörsaal 3

Ararat Stepanyan; Hovhannes Haroyan; Arsen Hakhoumian
Yerevan State University

This paper examines an electrically small microstrip patch antenna that is coated with a hemispherical magnetodielectric material (MDM). The study investigates the superdirectivity effect by simulating the behavior of the Huygens source. Through the incorporation of the magnetodielectric material, the microstrip patch antenna, operating at a center frequency of 12 GHz, is able to function effectively at 2.4 GHz. Experimental measurements reveal that the microstrip patch antenna, covered with a hemispherical magnetodielectric material, demonstrates multiband radiation with three times greater bandwidth and gain compared to an FR4 based common microstrip patch antenna. Additionally, the size of the antenna is reduced by a factor of 4.3.

14:10 - 15:50
Room 401
Krzysztof Nieweglowski

Focus Session Packaging

14:10 Aerosol-Jet-Printed Ramp-Based Interconnects from DC to D-Band

R. 401

Georg Gramlich; Uli Lemmer; Thomas Zwick; Akanksha Bhutani
Karlsruhe Institute of Technology

This paper explores the feasibility of ramp-based Aerosol Jet (AJ) printed interconnects for radio frequency applications from DC up to the D-Band (110 to 170 GHz). Utilizing off-the-shelf RF PCB materials, a proof-of-concept assembly was designed, fabricated, and tested. The interconnect was printed between two CPW segments on two PCBs placed on top of each other and connected by a ramp of 80 µm height and 200 µm length. Their performance was evaluated through measurements and was found to be in good agreement with the simulations. The results demonstrate a verified operational bandwidth of 153 GHz (DC to 153 GHz) with a return loss better than 10 dB and an insertion loss ranging from 0.31 dB to 1.41 dB. The reflection loss is better than 8 dB in the entire frequency range from DC to 170 GHz. A challenge in the fabrication process was the formation of a thin insulation layer on the CPW lines during ramp dispensing, which degraded the interconnect performance. This issue was mitigated through a novel glue scrubbing process by laser ablation, significantly improving the electrical contact and overall performance.

14:30 Design of an Antenna-in-Package for 180 GHz Chip-to-Chip Communication

R. 401

Mojtaba Sohrabi; Ran Yin; Dirk Plettemeier; Bernhard Klein; Krzysztof Nieweglowski; Karlheinz Bock
Dresden University of Technology

This paper presents the design of an 8 × 8 antenna array operating at 180 GHz for chip-to-chip and board-to-board communication. The work is developed as part of the E4C project, targeting high data rates and energy efficiency in short-range communication. The proposed system supports four communication links, demonstrating its

compatibility for energy-efficient applications in high-performance computing systems. By applying passive phase shifting and optimizing element spacing, the designed antenna achieves a minimum desired bandwidth of 30 GHz and a gain of 20.7 dB, 17.2 dB and 15 dB for link 1, 2 (link 2 and 3 using the same antenna) and link 4 respectively. Simulation results validate the performance, ensuring minimal mutual coupling between elements.

14:50 Glass and Structured Glass for High Frequency Electronics above 10 GHz

R. 401

Martin Letz
SCHOTT AG

Glasses are a material class on its own. Driven by the semiconductor industry cost efficient metallization processes on panel level (510 mm x 515 mm and larger) are currently developed, which show excellent adhesion of order 400 N/m and more. This allows to build electronic components and packages which can make use of the smooth glass surface. Glasses suitable for industrial glass panel production can be optimized with respect to their dielectric loss. We report on the status of the development of a low-loss glass with a loss-tangent tan(δ) @10GHz below 0.002 for microwave applications. Laser based structuring processes are highly accurate and are able to cut out hollow wave guide structures in glass with nearly ideally straight side walls. This allows to combine hollow waveguide components like e.g. filters and resonators with heterogeneous integration of active and passive components on the same glass substrate. In the current paper a number of examples for frequencies up to 130 GHz are shown.

15:10 Package Integrated Series-feed Antenna Arrays for mmWave Medical Radar Sensors

R. 401

Sriram Charan Pasupuleti; Thi Huyen Le; Ivan Ndip
Fraunhofer Institute for Reliability and Microintegration (IZM)

The modelling, fabrication, and measurement of package-integrated series-feed antenna arrays for mmWave medical radar sensors are presented. The Dolph-Chebyshev method to reduce the side lobe level below -20 dB. The impact of process variations of packaging technology on the impedance and radiation characteristics of the antenna also investigated. The investigations reveal that fluctuations in the dielectric constant and the patch-to-patch length dimensions are among the most critical parameters that can severely degrade the antenna performance.

Focus Session Photonics 1

14:10 - 15:50
Room 403
Kambiz Jamshidi

14:10 Integrated Ring Modulator Based High-Speed Optical Sampler for Wireless Signals

R. 403

Younus Mandalawi[1]; Mohamed I. Hosni[2]; Janosch Meier[1]; Souvaraj De[1]; Linjie Zhou[3]; Thomas Schneider[1]

[1] THz Photonics Group, Technische Universität Braunschweig, Braunschweig, Germany; [2] Optoelectronics Department, Military Technical College, Cairo, Egypt; [3] The State Key Laboratory, Shanghai Jiao Tong University, Shanghai 200240, China

We present a compact and energy-efficient high-speed optical sampler for wideband wireless signal reception. It relies on an integrated ring modulator (RM) to construct a photonics-assisted analog-to-digital convertor (PADC). The proposed scheme has the potential to overcome the bandwidth and resolution limitations of classic sample-and-hold based electronic ADC (EADC). The wireless signal is first converted to the optical domain and then sampled with the RM. Orthogonal sinc-pulse sequences, which are simultaneously generated in the same RM by a sinusoidal from a radio frequency oscillator, are used for optical sampling. The sampler down-converts the wireless signal with a bandwidth B into N sub-signals with a bandwidth of B/N. The sub-signals can then be processed with electronics with a bandwidth of B/(2N). This opens the door for wireless terabit transceivers.

14:30 Optical self-pulsing oscillations in passive silicon microring resonator on doped PN junction

R. 403

Abdou Shetewy; Weizhong Zhang; Menglong He; Kambiz Jamshidi
TU Dresden

In this work, we demonstrated experimentally the self-pulsing oscillations in silicon microring resonators (MRRs) with a frequency of 8 MHz. These oscillations are controlled by varying the optical power and detuning. This generated oscillation, with a microwave frequency range, can serve as a microwave oscillator to generate stable, high-frequency signals.

14:50 Optical Filter Roll-off Analysis for Orthogonal Sampling in a Direct Detection System

R. 403

Souvaraj De[1]; Janosch Meier[2]; Younus Mandalawi[2]; Abhinand Venugopalan[2]; Paulomi Mandal [2]; Ranjan Das [2]; Nora Meyne [3]; Kai Baaske [3]; Thomas Kleine-Ostmann[3]; Thomas Schneider[2]

[1] Physikalisch-Technische Bundesanstalt Braunschweig, TU Braunschweig;
[2] TU Braunschweig; [3] Physikalisch-Technische Bundesanstalt Braunschweig

A direct detection system requires a simple photodiode for the conversion from the optical to the electrical domain, only. However, orthogonal sampling is only possible in such systems if an optical filter is incorporated before the photodiode. Therefore, this paper investigates the dependence of the sampling quality on the roll-off factors of optical filters for an orthogonal sampling system based on a three-line frequency comb. The signal degradation is evaluated in terms of the root-mean-square error (RMSE), the signal-to-noise and distortion ratio (SINAD), and the effective number of bits (ENOB).

15:10 A Mach-Zehnder-Modulator based FMCW Lidar Emulator in C-Band

R. 403

Jan Brockmeier; Stephan Kruse; J. Christoph Scheytt
Heinz Nixdorf Institute, University of Paderborn

This paper presents a frequency modulated continuous wave (FMCW) light detection and ranging (lidar) system based on Mach-Zehnder-modulators (MZM). A thorough mathematical analysis is given to explain the basic operating principle of the system. To validate the system analysis, a laboratory setup implementing a lidar emulator in the optical C-band is built, and measurement results are given that confirm the theoretical predictions.

15:30 Energy efficient co-designed high-speed SiGe Driver for InP Mach-Zehnder modulator

R. 403

Jung Han Choi
Fraunhofer Heinrich Hertz Institute

This paper presents low-power and high-speed driver-IC developments for InP Mach-Zehnder modulator using a co-design technique. Two examples include an open-collector driver and 2-bit DAC using SiGe HBT technology. By exploiting the co-design technique, we can significantly reduce power consumption of the driver-IC and TOSA module. The open-collector and the 2-bit DAC consume 270 mW and 146 mW, respectively.

14:10 - 15:50
Hörsaal 4
Peter Knott

Radar 1

14:10 Efficient Bistatic Radar Processing Using Subsampled FMCW Ramps

Hörsaal 4

Julian Kanz[1]; Christian Gesell[1]; Martin Vossiek[2]; Christian Waldschmidt[1]
[1] Ulm University; [2] Friedrich-Alexander Universität Erlangen-Nürnberg

Bistatic radar places high demands on synchronization accuracy to ensure coherency in time, frequency and phase. The challenging synchronization requirements are circumvented by receiving the transmission signal on two paths and directly sampling the high-frequency signal without analog demodulation. In order to avoid large amounts of data and to enable sampling with slower ADCs, a concept is shown that allows subsampled frequency-modulated continuous-wave (FMCW) ramps to be evaluated without degradation of the performance. Bistatic radar measurements without any hardware synchronization are presented, demonstrating the coherent processing of up to 1024 times subsampled data without substantial loss in performance.

14:30 Random Scattering Modelling and Analysis by Machine Learning

Hörsaal 4

Yun Lu ; Sebastian Hegler; Michael Bärhold; Dirk Plettemeier
Dresden University of Technology

Microwave scattering in an arbitrary scene is inherently complex and highly sensitive. For a given target, its spectral response is primarily influenced by factors such as geometry and material properties. However, even a slight change in the angle between the radar and the target can significantly alter this response. As a result, it becomes challenging to classify targets based on a fixed reference coordinate system. This difficulty arises because microwave scattering responses are governed by a dynamic, unknown coordinate system that is inherently problem- and data-dependent. Therefore, extracting the coordinate system directly from the data is central to scattering analysis. This concept closely aligns with the principles of autoencoder

models in machine learning. Rather than analyzing scattering signals based on predefined reference responses (fixed coordinate systems), we adopt a "learning by doing" approach. Specifically, we extract a problem-dependent coordinate system—defined as kernels—directly from radar data, enabling more robust analysis of random scattering behavior.

14:50 Experimental Validation of Uniformly Undersampled Imaging in 6G D-Band with Interpolation Techniques

Hörsaal 4

Chia-Chi Lin; Hsin-Jung Yang; Ting-Yang Lin; Pei-Chen Yu; Shih-Yuan Chen
National Taiwan University

This article presents an experimental setup and validation of interpolation techniques for uniformly undersampled D-band planar imaging. Interpolation techniques, including our previously proposed rational thin-plate spline (RTPS) and the bicubic methods, are implemented on the scattered echoes, to mitigate spatial aliasing in reconstructed images. The reconstructed 2-D images are evaluated in both simulations and practical imaging scenarios to verify the achievable cross-range resolution. Both RTPS and bicubic interpolation demonstrated effectiveness for a uniform receiver array with sub-Nyquist spatial sampling interval of $1\lambda_c$. Imaging results show that the developed system can achieve millimeter-scale localization of targets with $1\lambda_c$ length at 150 GHz and resolve targets separated $2\lambda_c$ apart.

15:10 Analysis of Non-Homogenous Multiple Target Sparse Reconstruction in Through-the-Wall-Radar Imaging with Path-Loss Compensation

Hörsaal 4

Tumaini Edgar; Jacqueline Damas ; Abdi T. Abdalla
University of Dar es Salaam, Collage of Information and Communication Technologies

In Through-the-Wall Radar Imaging (TWRI), detecting targets behind walls is paramount for rescue and military operations. Nonetheless, path-loss—resulting from signal attenuation reduces the detectability of distant targets and poses a significant challenge. To mitigate this issue, researchers have formulated a path-loss compensator model that integrates the free space path-loss exponent, consequently enhancing image quality. However, existing literature predo-

minantly assumes the homogeneity of targets, which may not accurately reflect real world conditions. This study assesses the model's effectiveness for non-homogeneous targets utilizing MATLAB software. The results indicate that the path-loss compensator increases the Probability of Detection by 1.2% for two targets and by 0.9% for three targets with Gaussian distribution. Additionally, it improves the Signal-to-Clutter Ratio by 16.3% and 4% for configurations involving two and three targets, respectively. These enhancements highlight the model's potential for the reliable detection of targets with varying reflectivity, thereby rendering it applicable to practical TWRI scenarios.

14:10 - 15:50
Room 304

Workshop Rohde&Schwarz

14:10 Workshop On Microwave And Millimeter-Wave Characterisation Of Materials In 1-170GHz Range

R. 304

Marzena Olszewska-Placha[1]; Bartlomiej Salski[2]; Andreas Henkel[3]

[1] QWED Sp. Z o.o., Poland; [2] Warsaw University of Technology, Poland; [3] Rohde&Schwarz, Germany

This workshop focuses on presenting state-of-the-art and novel microwave and millimeter-wave material characterization techniques (1-170 GHz) using resonant methods. In part 1 we discuss measurement techniques for 1-30 GHz, focusing on dielectrics, semiconductors, and copper foils characterization using SPDR and Q-SCR. In part 2 the Fabry-Perot Open Resonators (FPOR) for wideband material characterization across 15-170 GHz is highlighted. Key Focus Areas of the workshop will be method advantages/limitations, measurement aspects, error, and uncertainty analysis. Practical Implementation: Presentations, hands-on session with device manufacturers/developers, and Vector Network Analyzer (VNA) operation training for material measurements.

Coffee Break

15:50 - 16:50
Rooms 101, 103, 105

Amplifiers 1

16:50 - 18:30
Hörsaal 4
Ingmar Kallfass

16:50 Hörsaal 4 60 GHz Radio Transceiver System for Energy Efficient Communication Systems

Daniel Georg Hellmich; Sonja Nozinic; Eugen Dischke; Deguang Sun; Adam Rämer; Wolfgang Heinrich; Viktor Krozer
Ferdinand-Braun-Institut gGmbH

Wireless transmission infrastructure for high data rates requires broadband radio links at millimeter-wave frequencies. In this paper, we present a modular 60 GHz transceiver system which is intended as intermediate frequency stage for an energy-efficient broadband link above 140 GHz. The transceiver converts signals from several modems in the 5 GHz Wireless Local Area Network band to 60 GHz using integrated chips for frequency conversion and signal amplification. Since energy efficiency is a key feature for 140 GHz broadband links, the modules are equipped with power monitors to measure the instantaneous power consumption of the individual transceiver components with high resolution in time. The presented 60 GHz transceiver system comprises a local oscillator based on a frequency synthesizer, a transmitter and a receiver module. The transmitter module provides conversion gain of 6.3 dB and a maximum output power of 16 dBm in the 60 GHz band. The receiver module provides conversion gain of 2.2 dB while the image frequency is suppressed by 23.7 dB. The entire transceiver system yields an error vector magnitude < 6% within its system bandwidth without error correction through coding.

17:10 Deep Learning-Assisted RFIC Design With Dual-Metal-Layer Passive Matching Networks: A 15-22 GHz CMOS PA for 6G in 22 nm FDX+

Hörsaal 4

Chenhao Chu; Edward Liu; Yuqi Liu; Boce Lin; Mohamed Eleraky; Basem Ali; Mohsen Ghorbanpoor; Tzu-Yuan Huang; Adam Wang; Hua Wang
ETH Zurich

Radio Frequency Integrated Circuit (RFIC) design requires human experts' experience and intuition. Tuning and optimizing passive matching networks (PMNs) using electromagnetic (EM) simulators are labor-intensive and time-consuming. Deep learning is a promising tool to expedite this process. However, data generation is usually computationally expensive, and difficult to fully explore the design space. In this article, we propose a template-guided approach for the data generation of dual-metal-layer PMNs, which is more practical than single-layer structures for CMOS RF/mm-Wave circuit implementations. A convolutional neural network (CNN)-based EM emulator is trained to expedite the evaluation process for rapid RFIC design. To validate the proposed design approach, a 15-22 GHz power amplifier (PA) is presented for sixth-generation (6G) frequency range 3 (FR3) applications, using the pixelated PMN from the proposed approach in the GlobalFoundries 22nm FDX+ process. This PA measures an OP1dB of 16.7-20.1 dBm, a PAEOP1dB of 24.4-30.6%, a Psat of 14.3-15.1 dBm, and a PAEsat of 26.3-35.8%. When tested with 5G FR2 OFDM 100-MHz 64-QAM signals, this PA achieves 6.61-7.83 dBm average.

17:30 A Ka-Band Power Amplifier in 130 nm SiGe using an Efficient Matching Network Design Method

Hörsaal 4

Alexander Haag[1]; Benjamin Sandrock[2]; Ahmet Cagri Ulusoy[1]

[1] Karlsruhe Institute of Technology (KIT)/ Institute of Radio Frequency Engineering and Electronics (IHE); [2] Robert Bosch GmbH, Germany

This paper presents the design of a very compact Ka-band power amplifier (PA) in 130 nm silicon germanium (SiGe) BiCMOS achieving an output power of 23.7 dBm and a power added efficiency (PAE) of 40% in class AB operation. A high performance is achieved through an improved approach on finding an optimized L/C-based matching network. Using this approach practical network efficiency limits can be calculated for all possible impedance transformations, enabling the assessment of network loss during the design process of power amplifiers.

17:50 A Differential Ka-Band PA with Transformer Matching in 250 nm SiGe BiCMOS

Hörsaal 4

Benjamin Sandrock[1]; Kaan Balaban[2]; Ahmet Çağri Ulusoy[2]

[1] Robert Bosch GmbH, Germany; [2] Karlsruhe Institute of Technology (KIT)/ Institute of Radio Frequency Engineering and Electronics (IHE)

In this paper the design of a fully differential Ka-Band power amplifier (PA) with transformer based impedance matching is presented. The PA is realized in a 250 nm SiGe BiCMOS process. At a target frequency of 28 GHz a maximum output power of 20.8 dBm and a PAE of 28.8 % are achieved demonstrating very high efficiency compared to implementations in similar technologies in the literature.

18:10 A Dual-Stage 15 GHz GaN Power Amplifier Using Capacitive Cross-Coupling Neutralization Technique

Hörsaal 4

Jamal Haider; Sohaib Yaqoob Chaudhry

National University of Sciences and Technology (NUST)

This paper presents a 15 GHz dual-stage push-pull neutralized PA using a 150 nm GaN process. The neutralization network is implemented using cross-coupled capacitors which help in increasing the gain. Marchand baluns are used at the input and output of the PA to

achieve the differential architecture with 50 Ω at all the ports. Compact LC matching networks are implemented to achieve the desired performance at 15GHz. The total size of the dual-stage PA MMIC is 3×1.6 mm². The DSPA demonstrates an output power of 39dBm with a PAE of 48% and a gain of around 32dB at 15GHz.

16:50 - 18:30
Hörsaal 3
Dirk Heberling

Antennas 2

16:50 UPD Printed 140 GHz Split Ring Resonator Antenna for Device-to-Device Communication

Hörsaal 3

Luca Valenziano; Elizabeth Bekker; Georg Gramlich; Thomas Zwick; Akanksha Bhutani

Karlsruhe Institute of Technology (KIT)

This paper presents the first ever printed antenna using ultra-precise dispensing (UPD) technology from XTPL, to the best of the author's knowledge. Furthermore, this paper demonstrates a solution to overcome the limitations of traditional printed circuit board (PCB) technology for high-frequency systems, by combining well-established PCB technology with a novel additive manufacturing method. In this work, we show the design, manufacturing, and measurement of a 140 GHz split ring resonator (SRR) antenna. The feeding structure and the matching network are realized by a wet-etching process on a commercially available PCB material. The actual radiating resonators with a minimum feature size of 12 µm are 3D-printed using UPD technology. A deviation to the designed dimensions of less than 2 µm is achieved. The printed antenna achieves a return loss better 10 dB from 119.8 GHz up to 155.4 GHz, resulting in a bandwidth of 35.6 GHz, corresponding to a relative bandwidth of 25.43%. A maximum gain of 4.5 dBi was measured at 136.5 GHz.

17:10 Geometrical and Physical Optics Analysis of Sub-THz Elliptical Dielectric Lens

Hörsaal 3

Vitor Carvalho de Almeida[1]; Ramez Askar[1]; Michael Peter[1]; Wilhelm Keusgen[2]
[1] Fraunhofer Heinrich Hertz Institute; [2] Technische Universitaet Berlin

This paper presents the Geometrical Optics (GO) and Physical Optics (PO) techniques for calculating the radiation pattern of a dielectric lens mounted on top of an open-ended WR6 waveguide. A ray tracing tool is used, and the far-field radiation pattern is calculated by applying Kirchhoff's Diffraction Theory on the lens surface. The results from the asymptotic methods are compared with full-wave simulation and far-field measurements at 160 GHz, with good agreement of the main lobe.

17:30 Increasing Gain of on-Chip Antennas Using Lenses

Hörsaal 3

Mojtaba Sohrabi; Michael Jenning; Dirk Plettemeier
Dresden University of Technology

On-Chip antennas often suffer from reduced performance due to the low resistivity and high permittivity of the semi-conductor material used. Complex or large integrated antenna designs are also impeded by strict technology requirements and prohibitive high costs. One simple way to increase the gain of integrated antennas is to employ lenses. We investigated lens designs for 280 GHz on-chip antennas.

17:50 Receiving Patch Antenna of a Phased Array Satellite Communication System

Hörsaal 3

Felix Kern; Dominik Klein; Christian Arnold
Tesat-Spacecom GmbH & Co. KG

This paper presents a phased array communication system for LoLaSat, focusing on the design and performance of a single patch antenna element of the receiving 6 x 8 phased-array. The sophisticated implementation of the communication modul on a single PCB with its key performance is presented in detail. Furthermore, simulaton and measurement results of the single patch antenna element around center frrequency of 29.7 GHz are presented.

18:10 A Hollow Dipole Antenna Design for Transmitting Data from Road-Integrated Sensors

Hörsaal 3

Maximilian Hermsdorf; Roman Salatov; Jitong Zhao; Marco Liebscher; Viktor Mechtcherine; Dirk Plettemeier
Dresden University of Technology

The wireless transmission of sensor data in order to monitor road layer conditions is crucial for the evaluation of road security and traffic networking in terms of V2I communication. In this paper, we present a compact transmission system that operates in the energy-efficient Narrowband Internet of things (NB-IoT) network and can be placed inside the road for communication with a roadside receiver. It features a small and robust form factor, a low cost design and a broad radiation characteristic favourable for additional communication links between multiple road-integrated transmission systems as part of a future V2I network. We present the design, simulations and measurements as a proof-of-concept.

16:50 - 18:30
Room 401
Ahmet Çağri Ulusoy

Control Circuits

16:50 A Broadband High-Gain 25–48-GHz Vector Modulator in a 130-nm BiCMOS Technology

R. 401

Leon Spiesshofer; Martin Sander; Carl Heine; Dietmar Kissinger
Ulm University, Germany

This paper presents a broadband bootstrapped frequency doubler followed by a static frequency divider-based IQ signal generation chain providing fully differential signals to variable gain amplifiers, creating a vector modulator. The maximum locking range is from 12.8 GHz to 49.1 GHz, corresponding to a 117% relative bandwidth. The system achieves a 3dB-bandwidth of 23 GHz (from 24.8 GHz to 47.8 GHz) with -7 dBm input power. The peak gain is greater than 30 dB and it exhibits low RMS phase and gain errors of less than 2.8° and 0.55 dB, respectively. The maximum output power of the vector modulator is 2.2 dBm.

17:10 Addressing Static Phase Offsets in High-Frequency Phase Detectors for Random Data Recovery

R. 401

Rabia Fatima Riaz; Ronny Henker; Frank Ellinger
Technische Universität Dresden, Germany

This paper presents a bang-bang phase detector (PD) and decision circuit specifically designed for random data recovery at 25 Gbps. To prove the concept, the circuits are implemented in 130 nm SiGe BiCMOS technology. The design addresses the challenge of removing static phase offsets between clock and data paths through careful layout considerations and current variations. Improved phase detection accuracy is achieved by optimizing and minimizing challenges such as signal path delays and process variations. The study includes detailed comparisons between pre-layout and post-layout simulations to demonstrate the reduction in phase offsets achieved through layout optimization. The adverse effects of process variations are removed by adjusting the bias current during measurements, resulting in a significant phase offset adjustment range of 85°. Additionally, the PD gain can be adjusted, providing flexibility in optimizing its performance for different operating conditions. This work advances the state-of-the-art in the design of PDs for high-speed data recovery systems for modern communication applications.

17:30 A sub-2 radix split-capacitor DAC for a 12bit SAR ADC in 28nm CMOS

R. 401

Sebastian Linnhoff[1]; Frowin Buballa[1]; Michael Reinhold[2]; Erik Sippel[3]; Friedel Gerfers[1]
[1] TU Berlin; [2] Robert Bosch GmbH; [3] FAU Erlangen-Nürnberg

This work presents the design and optimization of a sub-2 radix split-capacitor digital-to-analog converter (CDAC) utilized in a 333 MS/s 12 bit successive-approximation-register (SAR) analog-to-digital converter (ADC). Several techniques are proposed, enhancing the DAC settling and linearity performance during the SAR algorithm, including the use of a sub-2 radix redundancy, a split-capacitor CDAC and an extra reference-voltage scaling capacitor to maximize the reference-voltage to 1 V, directly reducing the CDAC switch impedance. The benefits and drawbacks of sub-2 radix CDAC realization are highlighted when adopting a 1.81-radix to maintain 12 bit settling accuracy with 10% overrange, covering capacitor mismatch and finite

settling accuracy. The proposed SAR ADC lane is utilized in a highly time-interleaved (TI) ADC chip manufactured in a 28 nm CMOS process. The chip is assembled on an interposer and finally packaged for simplified characterization. The SAR ADC achieves an excellent SNDR of 53.5 dB and 49 dB as well as a spurious free dynamic range (SFDR) of 71 dBc and 67 dBc for a 1 Vppd single tone sine wave input signal with a frequency of 90 MHz and 4 GHz respectively.

17:50 An Ultra-Compact Differential D-band Power Detector in a 90-nm BiCMOS Technology

R. 401

Lasse Cordes; Tobias T. Braun; Hakan Papurcu; Nils Pohl
Ruhr University Bochum

With its large bandwidth, the D-band is a promising frequency range for high-data-rate mobile communication. As 6G communication systems evolve, reliable Built-In-Self-Test mechanisms are essential to ensure system integrity and performance throughout their operation. In this paper, we present an ultra-compact differential D-band power detector with a core area of only 130 µm x 80 µm. It is implemented in a 90-nm BiCMOS technology using heterojunction bipolar transistors featuring an f_T/f_{max} of 300 GHz/520 GHz. The detector employs a common-emitter topology. Integrating into a capacitively tapped transmission line enables daisy chaining, facilitating easy integration into a 50 Ohm environment. The detector uses resistive emitter degeneration to linearize total input capacitance, mitigating intermodulation products in the passing signal caused by the transistor's nonlinear input capacitance. This design achieves a flat amplitude response across the entire D-band with a square-law dynamic range of up to 24 dB.

Focus Session Photonics 2

16:50 - 18:30
Room 403
Thomas Schneider

16:50 A W-band Down Conversion Mixer in EPIC 250 nm BiCMOS Technology for Monolithic Optoelectronic Radio Applications

R. 403

Enrico Jimenez Tuero[1]; Falk Korndörfer[1]; Andrea Malignaggi[1]; Friedel Gerfers[2]; Corrado Carta[3]

[1] IHP - Leibniz Institut für innovative Mikroelektronik; [2] Technische Universität Berlin; [3] IHP - Leibniz Institut für innovative Mikroelektronik, Technische Universität Berlin

This paper presents an active down conversion mixer operating in the W-band and implemented in the IHP SG25H5 photonics-enabled SiGe BiCMOS process, which enables the integration of optical and wireless communication systems in the same die. The circuit is realized with the 290 GHz f_{max} heterojunction bipolar transistors (HBTs) available in the process and arranged in a modified Gilbert-cell topology, where a current-bleed network consisting of resistive and inductive elements is employed to improve conversion gain (CG) and noise figure (NF). Powered with 66 mW from a 3.3 V supply, the fabricated prototype provides a peak conversion gain of 4.5 dB and a minimum NF of 13.5 dB over a 3-dB bandwidth (BW) of 24 GHz, spanning from 90 to 114 GHz. An input-referred compression point of -14 dBm was measured. While being realized with slower HBTs than designs previously reported in BiCMOS-only processes, the circuit performance is comparable with the state-of-the-art for silicon mixers operating above 100 GHz. In particular, the minimum NF is among the lowest reported for this class of mixers.

17:10 A High-Speed Linear Modulator Driver for 200-GBd PAM-4 with Low Group Delay Variation in 130-nm SiGe BiCMOS

R. 403

Robert Huber[1]; Lars Zimmermann[2]; Dietmar Kissinger[1]

[1] Ulm University; [2] IHP – Leibniz Institute for High Performance Microelectronics

A linear distributed modulator driver (DRV) designed and fabricated in a 130-nm SiGe BiCMOS technology with hetero-junction bipolar

transistors (HBTs) capable of a f_T/f_{max} of 350 and 450 GHz is presented for short-distance links up to 200 GBd PAM-4 to be integrated with Mach-Zehnder modulators (MZMs) or electro-absorption modulators (EAMs).
The driver is designed to maintain a flat group delay variation of ±1 ps up to 150 GHz while providing a low-frequency gain of 10.8 dB and a 3-dB bandwidth of 80 GHz.
At the 1-dB compression point and an input power of 0.5 dBm a voltage swing of 2.5 Vppd is achieved with a total harmonic distortion (THD) of 5%.

17:30 Orthogonal Data Aggregation with Jacobi Pulse Sequences

R. 403

Janosch Meier; Paulomi Mandal; Gouri Krishnan; Thomas Schneider
THz Photonics Group, Technical University Braunschweig

In this paper a new method for orthogonal data aggregation using Jacobi polynomial pulse sequences is proposed. First, the theory and construction of the sequences is presented. In proof-of-concept simulations we electrically aggregated 4 separate signals with 2 data levels and a data rate of 2 Gbit/s into a single 8 Gbit/s data signal with 16 data levels. Utilizing the Jacobi Polynomial pulse sequences a Q factor improvement of around 10 dB or a bandwidth reduction for the aggregated data signal by a factor of 1.5 could be achieved.

17:50 Characterization of Thermally Controlled Silicon Nitride Microring Resonator for the Generation of Optical Frequency Combs

R. 403

Menglong He; Mohd Saif Shaikh; Abdou Shetewy; Kambiz Jamshidi
TU Dresden, Germany

We investigate a thermally controlled silicon nitride microring resonator with anomalous dispersion for the generation of single- and dual-pumped optical frequency combs. Besides, the Kerr microresonator has been characterized by alternating the pump power and heater voltage. We also demonstrate the conditions of heater voltage to generate single-pumped optical parametric oscillation and then the transition to frequency combs. Moreover, the voltage-controllable single- and dual-pumped parametric conversion, including single- and dual-pumped Kerr comb generation, is then characterized.

18:10 GHz LSPR Modulation in Plasmonic Double-Resonance Nanoantennas due to Coherent Acoustic Vibrations

R. 403

Toni Haugwitz; Dirk Plettemeier
TU Dresden

The ability to modulate localized surface plasmon resonances in noble metal nanostructures using coherent acoustic vibrations opens up novel opportunities for optical communication by enabling fast and precise control over light signals at the nanoscale. However, plasmonic nanostructures designed for operation in the optical C/L band, such as single gold nanobars, are relatively large, leading to low vibration frequencies of only a few GHz. To overcome this limitation, near-field coupled plasmonic systems provide an alternative, offering more design flexibility and higher vibration frequencies through the integration of differently sized elements. This paper characterizes a plasmonic double-resonance nanoantenna that leverages this feature, with preliminary results demonstrating the feasibility of transmitting highfrequency vibration states into the optical communication band.

16:50 - 18:30
Room 201

Workshop Keysight

16:50 Advanced Methods for Measurements and Calibrations supporting Broadband 6G component test with Modern VNAs

R. 201

Joel Dunsmore; Axel Hahn
Keysight

Time to upgrade your understanding of what's possible: Substantial advances in modern VNA capabilities in the last two years to enable precise testing of 6G components, including fully characterization of S-parameters, Compression, Noise Figure and most particularly modulated measurements such as EVM. This workshop will detail the best practices for using VNAs with Sub-THz frequency extenders for standard S-parameter measurements and new capabilities to generate, calibrate, and measure complex modulated signals. This new capability is particularly important in sub-THz bands, where current state-of-the-art methods require generating base-band modulated signals and up-converting them to the sub-THz band; this process adds amplitude, phase and distortion errors. Using calibrated VNA-based measurements, these errors can be corrected using Digital Pre-Distortion (DPD) to generate pure modulated signals in these bands. Finally the bandwidths proposed for 6G are much wider (up to 20 GHz or more) than current signal analyzer capabilities in the industry, but using synchronous VNA measurement methods, we show demodulation capabilities, using Vector Spectrum Analysis software (Keysight's 89600 VSA) demonstrating less that 1% EVM floor at 250 GHZ center frequency. All of these techniques can be used without frequency extenders for lower frequency applications such as Ku and Ka band sat-com bands, and these will be discussed as well.

19:15 - 22:15
Dresden Transport Museum

Welcome Reception

Jan Gutzeit Photographer (DML-BY)

Tuesday, 18th of March

08:20 - 09:40	**Frontends and Sources**	Room 401
08:20 - 09:40	**Passive Components 1**	Hörsaal 4
08:20 - 09:40	**Workshop IHP 1**	Room 301
08:20 - 09:40	**Workshop Integrated Sensing & Communications**	Room 403
09:40 - 10:30	**Coffee Break**	101, 103, 105
10:10 - 12:10	**Poster Session 1**	Room 405
10:30 - 12:10	**Antennas 3**	Hörsaal 3
10:30 - 12:10	**Focus Session THz INTEREST**	Room 403
10:30 - 12:10	**Measurement and Calibration**	Room 401
10:30 - 12:10	**Passive Components 2**	Hörsaal 4
10:30 - 12:10	**Workshop IHP 2**	Room 301
12:10 - 13:20	**Lunch**	E01, E03, E05
13:20 - 13:50	**Keynote 3: Johan Wallblad**	Audimax
13:50 - 14:20	**Keynote 4: Corrado Carta**	Audimax
14:20 - 14:40	**Break**	
14:40 - 16:20	**Communication Systems**	Hörsaal 3

14:40 - 16:20	**Focus Session Semiconductor Technology**	Room 403
14:40 - 16:20	**Sensors 1**	Room 401
14:40 - 16:20	**THz Devices 1**	Hörsaal 4
14:40 - 16:20	**Workshop Anritsu**	Room 204
16:20 - 17:10	**Coffee Break**	101, 103, 105
17:10 - 18:30	**Radar 2**	Hörsaal 3
17:10 - 18:30	**Sensors 2**	Room 401
17:10 - 18:30	**THz Devices 2**	Hörsaal 4
17:10 - 18:30	**Workshop Tactile Internet**	Room 403
19:15 - 23:15	**Conference Dinner**	Löwensaal

Frontends and Sources

08:20 An Ultra Low Phase Noise Frequency Synthesizer with Optical Output for 77 GHz Photonic Radar

R. 401

Stephan Kruse; Vijayalakshmi Surendranath Shroff; Meysam Bahmanian; Jan Brockmeier; J. Christoph Scheytt

Paderborn University, Department of Electrical Engineering, Heinz Nixdorf Institute

This paper presents an ultra low phase noise frequency synthesizer with optical output for 77 GHz long range photonic radar. The system consist of an optoelectronic phase locked loop (OEPLL) using a mode locked laser (MLL) as reference clock, a frequency doubler for the upconversion to one half of the desired radar band, and an electrooptical (EO) modulator biased in the minimum point. The presented system achieves a channel spacing of 400 MHz in the frequency range from 74 GHz to 80 GHz. The phase noise after the optoelectronic (OE) conversion is better than -120 dBc/Hz at offset frequencies above 10 kHz.

08:40 Design of a Microwave Frontend for a Trapped Ion Quantum Computer

R. 401

Marvin Jäger; Georg Frederik Riemschneider; Nico Weiss; Bartosz Tegowski; Kölpin Alexander

Hamburg University of Technology (TUHH), Institute of High-Frequency Technology

Unlike classical computers, which represent information as binary '1' and '0', quantum computers use qubits that exist in a superposition of both, enabling parallel computation. This capability allows them to solve special kinds of problems faster than classical computers. To process information, qubits are manipulated by applying energy, such as via a microwave signal, which is provided by a microwave frontend that ensures an appropriate frequency spectrum and power level. This paper defines the key parameters and implements such a frontend for trapped ion quantum computers which follow the magnetic gradient induced coupling (MAGIC) principle. The frontend is manufactured on a printed circuit board and measurements prove its functionality. It achieves an idle gate fidelity of 99.9% (99.99%) at an output power of 6.32dBm (2.4 dBm).

09:00 A low phase noise Ka-band GHz VCO in 22nm FDSOI CMOS for 6G Applications

R. 401

Meghana Kadam[1]; Vadim Issakov[2]

[1] Technical University Braunschweig; [2] Institute for CMOS Design, Technical University Braunschweig

In this paper, we present a voltage-controlled oscillator (VCO) in 22 nm FDSOI CMOS technology for 6G wireless data communication systems. The VCO operates around a fundamental center frequency of 28.8 GHz. Additionally, it features the possibility to extract the second harmonic from the tail of the cross coupled pair. The circuit draws 39 mA from a single 800 mV DC supply. A very low phase noise of -104.3 dBc/Hz at 1 MHz carrier offset was measured at a frequency of 28.54 GHz. The output power measured on a 50 Ω load impedance is -5.5 dBm.

09:20 Design Strategies for Second Harmonic Gyrotrons in Nuclear Fusion Applications

R. 401

Lukas Feuerstein[1]; Jianbo Jin[1]; Konstantinos A. Avramidis[2]; Ioannis Chelis[2]; Stefan Illy[1]; Zisis C. Ioannidis[2]; John Jelonnek[1]; Moritz Misko[1]; Dimitrios Peponis[2]; Ioannis Tigelis[2]; Manfred Thumm[1]; Chuanren Wu[1]

[1] Karlsruhe Institut of Technology; [2] National and Kapodistrian University of Athens

Gyrotrons are high-power microwave sources that play an important role in the heating of plasmas for magnetically confined thermo-nuclear fusion applications. This paper presents a comprehensive study of two potential strategies for operating high-power mega-watt-class fusion gyrotrons at the second harmonic of the electron cyclotron frequency which requires only half of the gyrotron cavity magnetic field. The first approach focuses on a coaxial cavity design that effectively suppresses fundamental competing modes, making it a robust solution for second harmonic operation. The second strat-egy discusses the injection of an external locking signal. Therefore, a quasi-optical mode converter was designed and tested capable of handling both, co- and counter-rotating modes.

Passive Components 1

08:20 - 09:40
Hörsaal 4
Christian Damm

08:20 3D-Printed Surface-Mounted Waveguide Technology

Hörsaal 4

Bartosz Tegowski; Dominik Langer; Alexander Kölpin
Institute of High-Frequency Technology, Hamburg University of Technology

This contribution focuses on the 3D-printed surface-mounted waveguide (SM-WG) technology. In this concept, a printed circuit board (PCB) is combined with a 3D-printed metallized structure, complementing it to an on-PCB air-filled rectangular waveguide. For this, a nonradiative transition between a grounded coplanar waveguide (GCPW) and an SM-WG is developed, which serves as basis to feed SM-WG components. To connect the PCB with the SM-WG structure, a systematic assembly process based on a silver conductive epoxy adhesive is proposed. The concept is validated by a K-band quadrature hybrid Riblet-type coupler, which is designed, manufactured, and measured.

08:40 Dielectric Triple-Mode Filter Based on Additive Manufactured Zirconia Resonator

Hörsaal 4

Patrick Boe; Drilon Suka; Daniel Miek; Michael Höft
Christian-Albrechts-Universität zu Kiel

This paper presents the design, manufacturing, and electrical characterization of a dielectric triple-mode bandpass filter. The filter utilizes a triple-mode resonator based on the combination of a ring-shaped TE single-mode and a Y-shaped dual-mode dielectric resonator. For the realization of the resonator consisting of zircona, the cost-efficient Direct Ink Wrinting (DIW) approach is used. Simulations and practical measurements validate the design, showcasing the suitability of the approach to combine different basic resonator types for the realization of multi-mode structures.

09:00 Design and Measurement of a Low-Loss Bandpass Filter for Ku-Band in 45 nm SOI CMOS

Hörsaal 4

Evgenii Fedorov; Vadim Issakov
Technische Universität Braunschweig

This paper presents a preselector bandpass filter (BPF) designed for a high-power front-end module (FEM) targeting backhaul applications at Ku-Band frequencies 12-16 GHz. The proposed filter is intended for future integration into a high-power TX-RX switch module by combining it with an external 90° hybrid coupler. We implement an implicit filter capacitance in the RX mode by using a shunt NMOS transistors stack, which presents the C_{off} of the switches to the filter. Yet, in the TX mode the same NMOS stack provides a low-ohmic "short" path to ground by R_{on} and improves the switch module isolation. The presented circuit achieves in measurement a low insertion loss of 1.3 dB and a return loss better than 10 dB over the bandwidth. The chip is implemented in a 45 nm RFSOI CMOS technology and occupies an area of 0.31 mm², including pads.

09:20 Broadband Resistive Microstrip Directional Coupler

Hörsaal 4

Florian Stern; Wolfgang Taute; Michael Höft
Kiel University

This paper presents a novel broadband directional resistive coupler. A simple, low-cost coupler is designed for a project to measure moisture content with a fast network analyzer. A novel approach to directional coupler design is presented, which eliminates the need for ferrites and enables a nearly frequency-independent coupling of -16 dB. The innovative design, which works on the Wheatstone Bridge principle, uses crossed ohmic resistors on a Roger 4003C substrate and has a high bandwidth from 1 to 12.6 GHz with a directivity over 20 dB. The study combines simulations and practical implementations to validate the performance of the proposed directional coupler. A circuit board has been developed that uses two high bandwidth directional couplers to demonstrate its potential for microwave applications.

Workshop IHP 1

08:20 - 09:40
Room 301

08:20 IHP's Open Source SG13G2 PDK: Advancing RF and mm-Wave Design

R. 301

This workshop introduces IHP's open source SG13G2 Process Design Kit (PDK), designed to facilitate innovative and accessible integrated circuit design for academia and small-scale industry. The IHP OpenPDK offers a comprehensive feature set tailored to support collaborative design workflows and advance high-frequency applications.

The session will highlight the DI-DEMICO project, which utilizes the PDK to push the boundaries of RF and mm-wave design. Attendees will learn about key capabilities of the PDK, its role in enabling novel design methodologies, and its impact on research and development in high-frequency technologies.

By combining insights into open-source EDA tools with practical applications, this workshop provides participants an opportunity to explore cutting-edge advancements and discuss future possibilities in RF and mm-wave design.

08:20 - 09:40
Room 403
Padmanava Sen

Workshop Integrated Sensing & Communications

08:20 Integrated Sensing and Communications (ISAC): RF Hardware Enablement – antenna, front-end design and system-level perspectives

R. 403

Padmanava Sen; M. Sajjad Ahmad
Barkhausen Institut

This workshop focuses on the topic of hardware enablement for integrated sensing and communications (ISAC)/ Joint communications and radio sensing (JC&S) in the scope of upcoming 6G technology. The niche of ISAC technology in the future 6G ecosystem, as well as several potential applications, will be discussed in the context of hardware enablement. The different options depending on the frequency bands of use will be discussed. After presenting the state-of-art for the common communication and sensing frontend architectures and antenna options, potential candidates for the ISAC scenarios will be discussed. Self-interference-cancellation topic will be elaborated in detail as a key enabler for hardware reuse. A detailed analysis of the Key Performance Indicators (KPIs) for communication, radar, and joint systems will be covered. Insights on system level and measurement validation using specific test beds will also be given. Future perspectives and next steps on the path of enabling joint communication and sensing technology will be given at the end of this workshop.

09:40 - 10:30
Rooms 101, 103, 105

Coffee Break

Poster Session 1

10:10 - 12:10
Room 405
Dirk Plettemeier

10:10 A 240 GHz Down-Conversion Mixer in 0.13 µm SiGe BiCMOS Technology

R. 405

Kaan Balaban; Ekaterina Kunakovskaza; Ahmet Çağri Ulusoy
Karlsruhe Institute of Technology (KIT)

This paper presents an active, fundamental down – conversion mixer based on Gilbert cell topology at 240 GHz. It is implemented in a 0.13 µm SiGe BiCMOS technology with f_T/f_{max} of 300/450 GHz. For an LO power of -4 dBm at the frequency of 235 GHz and RF power of -30 dBm at 240 GHz, the maximum measured conversion gain and 1-dB compression point referred to input (IP1dB) are 9.4 dB and -10 dBm, respectively. The mixer core occupies an area of only 0.022 mm² and dissipates a power of 11 mW.

10:10 A 434 MHz Low-Power Receiver System Based on a Switched Passive Input Network With Surface Acoustic Wave Resonator

R. 405

Georg Meller[1]; Michael Methfessel[2]; Florian Protze[1]; Jens Wagner[1]; Frank Ellinger[1]

[1] Chair for Circuit Design and Network Theory, Technische Universität Dresden, Germany; [2] IHP – Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder), Germany

This work presents a low-power receiver in IHP SGB25V 250 nm BiCMOS technology. The analog frontend is based on a switched passive input network (SPIN) with a surface acoustic wave (SAW) resonator and receives on-off-keying signals with up to 100 kbps (measured). Due to bit-level duty cycling, it consumes only 640 nA (measured) from a 1.5 V supply at 10 kbps, which corresponds to a DC energy consumption of 96 pJ per bit. A digital backend performs detection of codes with a length of 63 bits with two-times oversampling and has a dynamic energy consumption of 11 pJ per bit (measured). The measured input sensitivity of the Rx system is -92.4 dBm (BER < 10^{-3}) and -95.4 dBm (CER < 10^{-3}) with 3 dB processing gain from the code. Since the bit rate is adjustable from 10 kbps up to 100 kbps, this Rx can be flexibly used either as a wake-up Rx (WuRx) or as a low-throughput data Rx.

10:10 On the Phase-Matching Design Condition of Distributed Amplifier Based Frequency Multiplier

R. 405

Stefan Simion
MTA – Ferdinand I

Single- and dual-fed distributed amplifiers based frequency multipliers are analysed for the phase-matching design condition. Based on the nonlinear circuit analysis, phase-matching design conditions are found such that the transistors have an equal contribution to the total output power and also the total output power level on the desired output harmonic is maximized. It is shown that the phase-matching design condition for the single-fed frequency multiplier cannot be used for dual-fed frequency multiplier. Although the phase-matching condition for the dual-feed frequency multiplier can also be used to design the single-feed frequency multiplier, this possibility cannot be recommended for the single-fed configuration as it leads to a longer layout of the circuit.

10:10 Compact 100 GHz to 300 GHz on-chip triplexer in SiGe HBT technique for subTHz channelization applications

R. 405

Xiaozhou Wang; Bernhard Klein; Dirk Plettemeier
Technische Universität Dresden, Germany

An on-chip triplexer is proposed to provide three passbands: Band1 95 GHz to 115 GHz, Band2 196 GHz to 215 GHz, Band3 292 GHz to 317 GHz to cover 100 GHz, 200 GHz and 300 GHz. The design achieves good compactness with dimensions of 0.79 mm × 0.64 mm (0.26 × 0.21 λ_0^2, where λ_0 is the free-space wavelength at 100 GHz) by employing openring stepped-impedance resonator (SIR) filters and folded lines. To further reduce the chip layout, a dual-band filter replaces the conventional two single-bandpass filters in the triplexer design. The channels, with bandwidths exceeding 10 GHz, exhibit out-of-band rejection greater than 20 dB. The triplexer was implemented based on the redistribution layer (RDL) of SiGe HBT technology. Measurements were conducted to validate the design, and key material properties: dielectric constant (Dk), loss tangent (Df), and surface roughness were optimized and incorporated into the simulations. A good agreement between measured and simulated results confirms the effectiveness of the design.

10:10 A Wideband SiGe D-Band Power Amplifier with 17.4 dBm Peak Output Power Featuring a Transformer-Based Load

R. 405

Stephan Hauptmeier[1]; Justin Romstadt[1]; Klaus Aufinger[2]; Nils Pohl[3]

[1] Ruhr-Universität Bochum, Germany; [2] Infineon Technologies AG; [3] Ruhr University Bochum, Germany / Fraunhofer FHR, Germany

In this paper, we present a D-band (110-170 GHz) power amplifier (PA) achieving a maximum output power of 17.4 dBm at a center frequency of 140 GHz. The PA exhibits a large 3 dB bandwidth of 53 GHz, reaching from 115 GHz to 168 GHz. Over the entire D-band, the saturated output power only varies by 5 dB. The circuit is designed in Infineons B12HFC 90 nm SiGe BiCMOS technology with an f_T and f_{max} of 300 GHz/500 GHz, respectively. The power amplifier consists of one gain and one power stage, which both utilize a fully differential cascode topology. A four-way power combining topology that takes advantage of transformer-based loads was designed. A maximum small signal gain of 18.2 dB was measured. S-parameter measurements and calculated stability factors prove the amplifier's stability.

10:10 A Power Amplifier for Electronic Photonic Integrated D-Band Radar Applications

R. 405

Deniz Tas[1]; Kai Scheller[2]; Amelie Hagelauer[1]; Marco Dietz[1]; Robert Weigel[2]

[1] Fraunhofer EMFT; [2] Lehrstuhl für Intelligente Elektronische Elektronik und Systeme (LITES), Friedrich-Alexander-Universität Erlangen-Nürnberg

In this work, a 3-stage power amplifier (PA) is implemented on an electronic photonic integrated circuit (EPIC) semiconductor technology. While silicon photonics are being found extensive usage in communication data center applications, there is a lack of research on their performance in wireless communication, radar, and sensing applications. This work describes the development and the evaluation of a power amplifier using IHP SiGe 250 nm BiCMOS EPIC technology. 5.5 dBm saturated output power was measured while the maximum power gain is 24.9 dB at 122.3 GHz and the 3 dB gain bandwidth is between 114 GHz to 134 GHz which is sufficient to cover ISM Band applications. The power amplifier consumes 157 mW and occupies 800 µm×300 µm core area and the total chip area is 1250 µm × 580 µm.

10:10 R. 405 3.6 GHz Reflection-type 360°-Phase-Tunable 3-Path Power-Divider with low Phase-Error up to 21.4 dBm Output Power per Path

Georg Simon Tanner; Maximilian Gottfried Becker; Marco Gunia; Frank Ellinger

TU Dresden

This article presents the analysis and design of a three-way 360° phase-tunable power divider for a frequency range from 3.4 to 3.8 GHz. In contrast to most publications on phase shifters, this paper studies high power aspects of reflective loads for application in reflect type phase shifter (RTPS) based topologies. Furthermore, the detrimental effect of asymmetric loads on the overall phase shifter performance is discussed. This results in the complete design of the phase-tunable divider incorporating switched line phase shifters and the RTPS allowing output powers up to 21.4 dBm while still providing the whole tuning range with little phase error over the full frequency band. Up to 19.2 dBm output power per path, the phase error is below 5°.

10:10 Towards a 240 GHz Megawatt-class Gyrotron for Proxima Alpha

R. 405

André Schmidt[1]; Lukas Feuerstein[1]; Stefan Illy[1]; Chuanren Wu[1]; John Jelonnek[1]; Manfred Thumm[1]; Lucio Milanese[2]; Jorrit Lion[2]

[1] Karlsruhe Institute of Technology; [2] Proxima Fusion

Karlsruhe Institute of Technology (KIT) is advancing the research and development of a short-pulse pre-prototype as the base for a continuous-wave (CW) industrial gyrotron with an output power exceeding 1 Megawatt (MW) at an operating frequency of around 240 GHz. It shall become the key component of an Electron Cyclotron Resonance Heating (ECRH) system for a future fusion power plant operating at a toroidal magnetic field of around 9 Tesla, specifically designed for Proxima Alpha. The pre-prototype shall be built-up and tested at the KIT FULGOR gyrotron test-facility, that will receive a 10.5 Tesla superconducting gyrotron magnet latest by 2025. This paper outlines the development for advancing the 240 GHz gyrotron. Possible designs are evaluated for their potential to manage the thermal loading, to minimize mode competition, and, to advance operating stability. The fundamental design choices and key challenges, including thermal management, cavity mode selection, and precision alignment, as well as simulation results for electron beam propagation and cavity performance are discussed.

10:10 Helically corrugated waveguide with dielectric lined drift section for a 263 GHz gyro-TWT

R. 405

Max Vöhringer[1]; Alexander Marek[2]; Stefan Illy[1]; Manfred Thumm[1]; Lukas Feuerstein[1]; Chuanren Wu[1]; John Jelonnek[1]

[1] Karlsruhe Institute of Technology (KIT); [2] Fraunhofer FHR (Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR)

Gyro-TWTs with helically corrugated interaction region (HCIR) have shown to be effective for broadband and high-power amplification of signals up to the W-band. In this publication, versions for 263 GHz (G-band) are proposed, which are able to generate above 1 kW of output power with a gain of 30 dB and 50 dB respectively. To avoid self-oscillations, a dielectric lined drift section is introduced and its effect on the interaction investigated. Furthermore, the effect of a non-ideal electron beam on the amplifier gain is examined. It is found that it has a great influence on the bandwidth; its influence on the maximum gain, however, is limited.

10:10 R. 405 5G Channel Performance in Licensed Spectrum: Experiments on an FRMCS Testbed

Charbel Lahoud; Shahab Ehsanfar; Hefdhallah Sakran; Klaus Mößner
TU Chemnitz

In this paper, we provide a comprehensive evaluation of 5G technology within the railway communication systems which holds immense promise for revolutionizing the efficiency, safety, and connectivity of the rail networks. In this study, we establish a test field to examine the behavior of 5G signals along railway tracks. Our study outlines the technical requirements for the implementation of 5G within future railway mobile communication system (FRMCS) infrastructures, encompassing critical factors such as physical layer (PHY) key performance indicators (KPI), reliability, coverage, and specific usage scenarios. Through testbed outdoor measurements, we compare empirical findings with predefined models to discern the efficacy of 5G in railway environments. This research offers valuable insights into the viability and potential challenges of integrating 5G within the railway industry, paving the way for enhanced operational efficiency and passenger experience in the future of rail transport.

10:10 R. 405 Saving Space on Satellites: Comparing a Q-Band TWTA Amplifier Assembly to a Highly Integrated SSPA Solution

Lukas Wachter
Tesat-Spacecom GmbH & Co. KG

This paper compares two different Q-Band (37 GHz to 42 GHz) satellite downlink assemblies: One with traveling wave tube amplifiers (TWTAs) and one with semiconductor power amplifiers (SSPA, solid state power amplifier). While the former is established and widely used on geostationary telecommunication satellites, it is comparatively large and heavy. The SSPA-solution has comparable electrical performance for a fraction of the space used on the satellite. The SSPA has a slightly lower output power than the TWTA and is less efficient, but performs very similarly with regards to linearity, while using less than half of the space previously occupied by the TWTA-assembly, cutting the weight by over 40% as well.

10:10 An Approach to Wireless ECG Monitoring

R. 405

Tony Bauer[1]; Nora Herzog[2]; Nick Schwarzenberg[1]; Max Greiner[1]; Alexander Laß[1]; Dirk Plettemeier[1]

[1] Technische Universität Dresden; [2] Universitätsklinikum Carl Gustav Carus Dresden

Electrocardiography (ECG) is a critical diagnostic tool widely used for assessing cardiac health. The standard 12-lead ECG setup requires the placement of 10 electrodes on the patient's body, which is a time-consuming process prone to placement errors and discomfort. The multitude of cables not only complicates electrode attachment but also restricts patient mobility, as the system is often tethered to a large unit that must be carried during monitoring. This setup limits the effectiveness of continuous monitoring and increases patient inconvenience. Consequently, there is a significant need for more efficient, error-resistant, and patient-friendly ECG monitoring solutions that maintain diagnostic accuracy while improving ease of use and mobility. This paper presents a new on-body ECG monitoring system that uses the EASI electrode configuration and wireless data transfer. This approach addresses the limitations of traditional 12-lead ECGs, improving ease of use and patient mobility while maintaining diagnostic accuracy.

10:10 Non-Invasive Wearable Microwave Sensing for Sarcopenia and Sarcopenic Obesity

R. 405

Robin Augustine[1]; Bappaditya Mandal[1]; Mr. Adarsh Singh Mtech[2]; Debasis Mitra[2]; Taco Blokhuis[3]

[1] Uppsala University; [2] Dept. of ETCE, IIEST Shibpur; [3] Maastricht University Medical Centre+

This article introduces a portable, non-invasive, and cost-effective microwave sensing system designed to diagnose and monitor sarcopenia and sarcopenic obesity. The sensor system employs a pair of bow-tie antennas with resonance-based reflectors in a wearable configuration strategically positioned mainly on the thigh region of the human body. The chosen placements ensure optimal proximity to major muscle groups, enabling precise and reliable data acquisition. The system captures transmission coefficient magnitude and phase parameters to assess muscle quality and body composition. Advanced electromagnetic simulations are conducted using 3D human body models in CST Microwave Studio to validate the system. These models incorporate anatomically realistic tissue properties and are used to optimize sensor design and placement. The sensor's ability to measure changes in dielectric properties associated with muscle and fat content provides a novel, safe, and repeatable method for evaluating musculoskeletal health.

10:10 A Miniaturized Unidirectional On-Body Antenna for Ultra-Wideband Electromagnetic Medical Applications

R. 405

Abdul Quddious; Michael Bärhold; Petr Schaffer; Marco Mütze; Dirk Plettemeier

Technische Universität Dresden, Germany

A miniaturized, unidirectional on-body antenna designed for ultra-wideband (UWB) electromagnetic (EM) medical applications is proposed. The antenna is optimized for high-permittivity human tissues, the design delivers a wide impedance bandwidth of 170% (0.5–7 GHz) and unidirectional near-field radiation, making it suitable for both deep-tissue and surface-level medical applications. The proposed antenna achieves a compact size (502 mm³) by employing multiple radiating modes excited through the shorted ring and shorted parasitic patch. Comprehensive simulations and measurements, including testing on homogeneous and multi-tissue realistic human

body models were performed demonstrating effective power penetration and good matching across a broad frequency range 0.5–7 GHz. The proposed miniaturized on-body antenna with unidirectional pattern, and UWB bandwidth underline its potential for applications such as EM biomedical diagnosis and wireless body area networks.

10:10 Performance Analysis in a Digital TETRA-Simulcast System

R. 405

Marcel Neumaier[1]; Anne-Catherine Probst[1]; Maximilian Wölfel[2]; Ulrich Bochtler[1]

[1] University of Applied Sciences Aschaffenburg; [2] Kaitec GmbH

In radio communication of mission-critical services, resilient solutions are strongly required to account for public safety. Additionally to the cellular network based on the professional mobile radio European standard TETRA, a digital TETRA-simulcast system is proposed as a redundant network to ensure area coverage in case of base station failure caused e.g. by disasters. This paper presents a preliminary study about network planning of a frequency-efficient digital TETRA-simulcast system to be physically deployed in a hilly region of Germany. Coverage as well as ray tracing analysis and channel modeling were performed by simulations and prove to be helpful tools for the systematic optimization of system performances, especially with regard to the control of intersymbol interference in overlapping zones.

10:10 A 21 GHz Bandwidth 30 dB Gain VGA for 6G Baseband Systems in 22 nm FDSOI

R. 405

Philip Hetterle; Andre Engelmann; Kai Scheller; Tianzhu Huang; Robert Weigel; Norman Franchi

Friedrich-Alexander-Universität Erlangen-Nürnberg

This paper presents a 5-stage wideband variable gain amplifier (VGA) integrated in 22 nm fully-depleted silicon-on-insulator (FDSOI) CMOS technology. The circuit comprises three different core circuit topologies, composed by an input buffer, three gain control stages and a high-power ouput stage. The VGA achieves 30 dB gain with a power consumption of 44 mW, exhibiting a continuous tuning range of 33 dB, covering a 3 dB bandwidth of 21 GHz, while occupying an area of 0.077 mm². The VGA is optimized for operation within high-data rate 6G receiver systems.

10:10 NO_2 detection via microwave-based gas sensor with SnO_2 deposited by ALD

R. 405

Artur Rydosz

AGH University of Krakow, Krakow, Poland

In this paper, the gas-sensing characteristics of the tin dioxide (SnO_2) gas-sensitive layer, deposited by atomic layer deposition (ALD), in the microwave frequency range are presented and discussed. The microwave-based gas sensor was previously designed in the form of a meander-type transmission line working at 5.8 GHz with an eight-port reflectometer part and tested with several MOX films. At the same time, ALD has not been reported yet in microwave-based gas-sensing applications. The sensor was tested in the 0-10 ppm range of nitrogen dioxide at various relative humidity (RH) and operating temperatures (OT). The measured limit of detection (LOD) was as low as 0.05 ppm while the estimated LOD could reach 0.005 ppm. The obtained results can be used to further optimize the microwave-based sensing elements for various applications, including gas sensors where high relative humidity levels are expected to exist.

10:10 Simulation of Radar Baseband Signals From a System-Theoretical Perspective

R. 405

Tim Poguntke[1]; Karlheinz Ochs[2]; Thomas Zeh[1]

[1] Kempten University of Applied Sciences; [2] Ruhr Universität Bochum

The simulation of radar baseband signals is crucial for the development of new radar applications, especially when radar sensors are supposed to measure time-varying scenarios. This paper proposes to investigate the measurement problem from a system-theoretical perspective by regarding radar channels as linear time-variant systems such that the presented approach becomes independent from specific radar modulation schemes. In order to demonstrate that the provided methods are generally applicable, we show how it is applied using conventional modulation techniques based on Linear Frequency Modulated and Orthogonal Frequency Division Multiplexing signals. By using the proposed method to simulate a simple radar channel with one moving point target, we demonstrate that the presented results are easily applicable and that they can be extended even without having a deep system-theoretical background.

10:10 Broadband Dielectric Characterization of Road and Pavement Materials

R. 405

Sebastian Hegler; Maximilian Hermsdorf; Gustavo Alfonso Canon Falla; Dirk Plettemeier

Technische Universität Dresden

The use of multifunctional sensor materials in roads requires transmission of measured sensor data. To achieve this goal, the dielectric properties of these novel materials must be known. The state of the art of a measurement setup to characterize road and pavement materials, as well as first measurements with asphalt samples, are presented in the following.

10:10 Over-the-Air Measured Reflective and Transmissive Properties of Glass and Plastic Materials at 110–330 GHz

R. 405

Kimmo Rasilainen; Muhammad Ibrahim; Mikko Kokkonen; Sami Myllymäki; Klaus Nevala; Aarno Pärssinen; Marko E. Leinonen

University of Oulu

Coming ultra-high data rate 6G networks will be deployed to sub-THz frequencies where enough contiguous spectrum can be found for these. Together with technological challenges of sub-THz RF components, the importance of understanding the propagation environment and the effect of materials on such radio link performances significantly increases. This work presents an experimental study of reflective and transmissive properties of different window glass and plastic materials using an over-the-air characterisation technique at sub-THz frequencies (110–330 GHz). Here, transmissive properties are represented in terms of transmission loss. The results show that some of the studied materials demonstrate transmission losses above 30–40 dB, which may require particular attention for reliable network deployments.

Antennas 3

10:30 Dual Aperture Coupling: A Novel Feeding Method for 180 GHz Antenna Array

Hörsaal 3

Mojtaba Sohrabi; Bernhard Klein; Dirk Plettemeier
Dresden University of Technology

This paper presents a novel on-wafer measurement technique for characterizing a 180 GHz antenna array. The proposed antenna consists of an aperture coupled driven patch stacked with a parasitic patch. A matching network utilizing an aperture is optimized for a designed GSG probe pad, enabling precise energy coupling from the antenna to the measurement port. Simulation results demonstrate a wide bandwidth of 16% over the operational frequency range of 168 GHz to 197 GHz. Detailed simulation results of the antenna design are presented, along with experimental plans to validate the dual aperture coupling technique.

10:50 Beamforming Multi-Element Near-Field Probe Scales to Measuring Large Phased Arrays

Hörsaal 3

Thomas Deckert[1]; Lukas Kaimann[2]; Mattia Piana[3]; Marc Vanden Bossche[4]; Martin Obermaier[5]; Dirk Plettemeier[5]
[1] National Instruments Dresden GmbH; [2] Karlsruhe Institut of Technology; [3] University of Padova; [4] Comvadis NV; [5] Technical University Dresden

Over-the-Air measurements are critical for the validation of active antenna arrays. A novel over-the-air near-field measurement approach was presented that targets specifically the validation and test of 5G mmWave antenna modules. It provides the equivalent quantities as known from classical chamber-based far-field measurements but with a significantly reduced form factor, at lower costs, and with higher measurement speed. This is accomplished by using an array of near-field probes and an algorithm to map near-field measurements to far-field properties. For measuring the receiver characteristics of an active antenna, the early prototypes of this new technique require a number of instrumentation channels commensurate with the number of near-field probes being used. This may become prohi-

bitively expensive. In this paper we propose an algorithmic extension of the original method that would require only one channel (per polarization) in combination with a beamforming/phase shifting network on the probe array side. We use measurement results to show the effectiveness of the method.

11:10 Design and Implementation of CP Antennas for Automotive and Radar Applications at 76.5 GHz

Hörsaal 3

A.M.M.A. Allam[1]; Moustafa S. A. Mohamed[1]; Basel Ahmed[1]; Wassim Alexan[1]; Dina El-Damak[1]; Diaa Fawzy [2]

[1] Faculty of Information Engineering and Technology, German University in Cairo, Egypt; [2] Faculty of Engineering, Izmir University of Economics, Izmir, Turkey

This paper introduces an antenna to be deployed in autonomous vehicles applications and Multiple-Input Multiple- Output (MIMO) radar systems. Such radar technology has revolutionized the field of radar systems by leveraging multiple transmitting and receiving antennas to enhance detection capabilities and improve resolution. This research focuses on the design, implementation, and performance evaluation of MIMO radar antennas, highlighting their potential to significantly advance the state-of-the-art in radar technology. The antenna is constructed on Rogers RO4003C, which has a relative dielectric constant of 3.55 and a thickness of 0.203 mm. The single and multiple circularly polarized wide-band antenna configurations are presented, operating at 76.5 GHz to meet the application requirements. One of these antennas was chosen for fabrication which conducts a strong correlation between the simulated and measured reflection coefficient. In addition, parameters such as 2D radiation pattern, realized gain, and the axial ratio are detailed. The achievement of the practical band and the radiation pattern features for automotive and radar systems are presented.

11:30 Quad-Band Diplexing Filtennas with Reciprocal/ Orthogonal Feeding Types for Radiation Pattern Diversity

Hörsaal 3

Al Amin; Alper Turkeli; Ali Kursad Gorur

Nevsehir Haci Bektas Veli University

In this article, novel quad-channel diplexing antennas based on capacitor-loaded co-directional split ring resonators (CDSRRs) are

proposed. For this purpose, a wideband circular monopole antenna is firstly designed to cover the frequency range from 3 to 6 GHz, where the channels will be located. Four pairs of CDSRRs are coupled to the feeding lines from two sides of the circular patch to obtain highly selective four channels. Since a single CDSRR can create two resonant frequencies, all channels consist of two reflection zeros. For experimental demonstration, two diplexing antennas having reciprocal (in-line) and orthogonal (perpendicular) port connections for variable radiation patterns were implemented and measured with the fair agreement with the predicted results. The center frequencies of the reciprocal/orthogonal diplexing antennas are almost the same and were measured at 3.3/3.35, 3.98/4.05, 4.67/4.8, and 5.72/5.76 GHz.

11:50 Design of a Holographic Standing-Wave Antenna

Hörsaal 3

Somayeh Saeidi; Mohammad Amin Chaychi Zadeh; Sajjad Zohrevand; Nader Komjani; Vahid Nayyeri

Iran University of Science and Technology

In this paper for the first time, design approach of a standing-wave antenna based on holographic technique is presented. To the best knowledge of the authors, no holographic standing-wave antenna (HSWA) design has been reported, yet. In the design process, the amplitude and phase of reference wave are extracted, carefully. A center-fed holographic antenna with the broadside radiation at the frequency operation of 18 GHz is designed. The HSWA consists of grounded hexagonal unit-cells with the side length of about $0.08\lambda_0$. The HSWA is implemented on Rogers RO4003C substrate with the thickness of 0.528 mm. The realized gain and aperture efficiency of the proposed compact antenna are 15.8 dBi and 75%, respectively.

Focus Session THz INTEREST

10:30 - 12:10
Room 403
Justin Romstadt

10:30 Design and Validation of Enhanced Fixtures for THz Dielectric Waveguide Sensors and Applications

R. 403

Kristof Dausien; Irwin Barengolts; Francesca Schenkel; Jan Barowski; Christoph Baer; Ilona Rolfes; Christian Schulz
Ruhr University Bochum

In this paper, we present the design, validation, and characterization of effective fixtures for 3D-printed dielectric waveguides (DWGs) operating in the sub-THz to THz domain. To minimize interference with DWG performance, various layer heights were designed and analyzed using a 3D full-wave electromagnetic (EM) solver. An innovative 3D-printed fixture, termed the RF-brim, provides an efficient solution by securely supporting DWGs in a floating configuration. This design minimizes signal loss and suppresses the propagation of higher-order modes. Additionally, the RF-brim offers scalability, enabling its use in large sensoric, antenna, or fluidic channel applications without disrupting signal propagation. To validate the simulation results, experimental measurements were conducted, highlighting the fabrication limitations of different fixtures, primarily influenced by variations in layer size.

10:50 Artificial Material Parameter Analysis Using a Realistic Model of the Transmission Reflection Method

R. 403

Manuel Funk; Irwin Barengolts; Jan Barowski; Christian Schulz; Ilona Rolfes
Ruhr University Bochum

Material characterization is an integral part of many applications in electrical engineering and other fields, such as medicine or biotechnology. One possible implementation is the transmission reflection method, which is used to determine both the real and imaginary part of a material sample with high precision. In this work, a simula-

tion model based on the transmission reflection method is derived from real measurement data in a free-space setup for material characterization. The model is used to generate realistic scattering parameters of artificial materials with selected dielectric properties and thicknesses in the frequency range from 70-170 GHz. These are subsequently characterized and the permissible material parameters are determined.

11:10 On the use of SiGe MMIC based VNA Extension Modules in the scope of Material Characterization

R. 403

Justin Romstadt[1]; Ilona Rolfes[2]; Nils Pohl[1]; Jan Barowski[2]

[1] Institute of integrated Systems, Ruhr University Bochum, Germany; [2] Institute of Microwave Systems, Ruhr University Bochum, Bochum, Germany

This paper presents the evaluation of Silicon-Germanium (SiGe) MMIC based frequency extension modules for vector network analyzers in the scope of material characterization. The performance of the MMIC based extension modules is compared to a state-of-the-art commercial extension module in the D-band (110 GHz to 170 GHz). The measurements are conducted using a corrugated horn based material characterization kit (MCK) from SwissTo12. The dynamic range of the measurement setup is assessed after calibration. The results of the material measurements are compared and discussed. The relative permittivity and loss tangent of a silicon wafer, a Polypropylen plate and a ceramic absorber tile are determined and compared. The results of the materials under test are found to be in good agreement. The presented MMIC based frequency extension modules provide a cost effective and compact alternative to conventional extension modules for material characterization measurements.

11:30 Ultra-high resolution tunable chip-integrated photonic delay line for THz Time-Domain Spectrometer

R. 403

Sujay Ashok Charania; Dirk Plettemeier
Technische Universität Dresden

Generation of a compact, ultra-high-resolution tunable chip-integrated delay line is one of the greatest challenges in the modern photonics system design. It is a key building block for realizing broadband optical communication systems, phased-array antennas, photonic signal processing systems, optical coherence tomography, and THz time domain spectroscopy. In this paper, a network of low-loss optical waveguides, and efficient optical switches is proposed to achieve fs laser pulse delay with a total delay of 18.5 ps with resolution of 36 fs. The envisioned THz time domain spectrometer is being designed to target the frequency range from 0.3 THz to 30 THz with a resolution of 100 GHz. This can be realized using the proposed tunable delay line architecture.

11:50 Sub-nm resolution ultra-broadband photonic on-chip spectrometer

R. 403

Sujay Ashok Charania; Sourav Dev; Kambiz Jamshidi; Dirk Plettemeier
Technische Universität Dresden

An ultra-broadband spectrometer with high resolution comprising of on-chip photonic components is proposed here. The spectrometer design consists of cascaded Mach Zehnder interferometers, tunable high-Q ring resonators, and arrayed waveguide grating wavelength filters. The multi-stage design filter showcases the spectrum retrieval process for a 100 nm wide unknown spectrum centered around 1550 nm input via a single optical input and filters over 8 optical output channels with 200 pm resolution. This makes the ratio of spectral bandwidth to resolution to be 500, which is among the highest figure of merit for such a broadband on-chip spectrometer.

Measurement and Calibration

10:30 A New Approach to Load Pull

R. 401

Markus Lörner[1]; Marcel Valcan[2]
[1] Rohde & Schwarz International GmbH; [2] Rohde & Schwarz GmbH

RF frontends and amplifiers are tested more and more with real application conditions. Today, this drives the usage of wideband modulation stimuli. The next level of real application conditions is to look at dispersive impedances as presented to the output of the RF frontend. This paper brings these to important item together.

10:50 Frequency Selective Gain and Distortion Analysis with Standard Compliant Test Signals

R. 401

Markus Rullmann; Vincent Kotzsch
National Instruments Dresden GmbH

We present a simplified method to extract the frequency dependent gain from wideband modulated signals. Based on our wideband vector measurement system, the method is used to extract the complex linear gain for the large signal operation point of complex non-linear devices for modern communication systems. It allows the characterization of noise and non-linear distortion from a single, dense modulation signal – without adding further complexity to the signal generation procedures. The experimental results show very good alignment with classic multisine measurements within 0.1dB gain error. The main benefits of using a single realization are the flexibility in utilizing real application signals, reduction in measurement time and memory by a factor of 10, and better control of the DUTs large signal operating point.

11:10 Multi-Waveguide Band Characterization of a 6G Terahertz Frontend

R. 401

Benjamin Schoch[1]; Dominik Wrana [1]; Simon Haussmann [1]; Laurenz John[2]; Jean-Pierre Teyssier[3]; Ingmar Kallfass[1]

[1] Institute of Robust Power Semiconductor Systems (ILH) - University of Stuttgart; [2] Fraunhofer Institute for Applied Solid State Physics IAF, Germany; [3] Keysight Technologies, USA

This paper presents a novel measurement setup for simultaneous characterization of a 300 GHz transceiver at IF and RF frequency reference planes where IF and RF lie in different waveguide bands. This setup is used for mapping time-domain signal quality measures, such as the error vector magnitude, to the nonlinear frequency-domain magnitude and phase characteristics. The measurement setup has to be carefully built with detailed configuration to enable vector averaging and source correction. Furthermore, a procedure for utilizing multiple frequency bands within a single configuration is delineated. The paper presents a detailed analysis of the signal quality within a H-band communication system, illustrating the calibrated input and the output of the transmitter, along with the received and down-converted signal at the receiver side. In order to facilitate characterization, 16-QAM and 64-QAM modulated signals with a 5 GBd symbol rate are employed. The input signal was pre-distorted achieving an EVM of 0.8% in WR-10 band, where the output could be measured to 4% and 4.8% at the Tx output in WR-3.4 band and at the Rx output in WR-10 band, respectively.

11:30 W-band Noise Figure using Novel VNA Extender and Novel Switched LNA

R. 401

Joel Dunsmore; Suren Singh; Bernadette Smith; Han-Chern Hoe

Keysight Technologies

Noise figure measurements using Vector Network Analyzers (VNA) are widely accepted, and available up through 70 GHz. However, for the upper end of V-band, E-band and all of W-band noise-figure measurements, there does not exist a convenient solution. Here we present a novel configuration of a mm VNA extender head, along with a novel switched LNA, that together provide a convenient method for measuring NF in these bands, while maintaining the ability to measure all other aspects of the amplifier under test, including full S-parameters and gain compression. The measurement system noise figure is shown to be 19 dB.

11:50 Bistatic Polarimetric Measurements of Reconfigurable Intelligent Surfaces

R. 401

Florian Reher[1]; Henrik Jansen[1]; Markus Heinrichs[2]; Tobias Falk Nowack[3]; Masoumeh Pourjafarian[3]; Rainer Kronberger[2]; Matthias A. Hein[3]; Dirk Heberling[1]

[1] RWTH Aachen University; [2] TH Koeln; [3] TU Ilmenau

The characterization of Reconfigurable Intelligent Surfaces (RIS) poses a challenge to conventional antenna and RCS measurement ranges due to the need to measure propagation paths towards and from geometrically unlinked directions. The bistatic radar measurement setup (BIRA) at the Thuringian Center of Innovation in Mobility is well-suited for bistatic far-field measurements during the research phase of the sixth generation of mobile communications. This setup comprises an eight-axis positioning system with two independent probes mounted on gantry arms, effectively mitigating geometric limitations. The facility was used to characterize a set of binary reconfigurable reflective surfaces to benchmark an innovative unit cell design in the C-band and to examine polarization-dependent characteristics.

10:30 - 12:10
Hörsaal 4
Alexander Kölpin

Passive Components 2

10:30 Performance Comparison of Two D-Band E-Plane Cut Waveguide Filters with Complex and Imaginary Transmission Zeros

Hörsaal 4

Daniel Miek; Patrick Boe; Michael Höft
Christian-Albrechts-Universität zu Kiel

This paper compares the performance of two eighth-order waveguide filters in D-band. Both filters have a complex pair of transmission zeros, which is used for phase equalization, as well as an imaginary transmission zero pair for blocking improvement in the near passband region. The filters are designed in order to be manufactured in E-plane cut, which reduces the insertion loss compared to H-plane-cut manufacturing. Both filters are designed in a way that a quadru-

plet section implements the complex transmission zero pair. However, they distinguish each other by the realization of the imaginary transmission zeros. While one filter consists of a second quadruplet section, the other filter has two stub-loaded cavities. The flexibility of both approaches is discussed and a performance comparison of manufactured prototypes takes place.

10:50 Sub-THz Waveguide Band-Pass Filter: Design, Analysis and Fabrication Repeatability

Hörsaal 4

Mehmet Ahad Yurtoglu; Ramez Askar; Sven Wittig; Michael Peter
Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI

This paper presents two units of Y-band (325-500 GHz) and two units of D-band (110-170 GHz) all-pole inline Chebyshev band-pass filters (BPFs) using high-precision computer numerically controlled milling. The filters are based on six-coupled resonant cavities and are designed for a 20 dB return loss in a 10 GHz bandwidth centered around 470 GHz and 160 GHz with two taper sections at the input and output. Statistical analyses of the design parameters are performed to estimate the manufacturing tolerance. Microscope measurements are done and it is seen that machine tolerance on cavity lengths of about 3.5 microns causes a 2 GHz center frequency shift in Y-band. Measurements validate the analyses. The fabrication repeatability in the D-band is more consistent than in the Y-band. Indeed, two Y-band BPF units have a center frequency shift difference of 6 GHz while the the D-band BPF units have almost identical responses.

11:10 Closed-Form Quasi-Static Solution for Capacitance and Conductance of Coplanar Waveguides

Hörsaal 4

Raik Elster; Manuel Wittlinger; Wolfgang Vogel; Manfred Berroth; Georg Rademacher

University of Stuttgart

We present a closed-form quasi-static model for calculating the distributed capacitance and conductance of a coplanar waveguide (CPW) with finite-width ground electrodes on a two-layer substrate. The presented approach uses the conformal mapping technique and enables calculating these parameters for substrates, where the dielectric permittivity of the layers is increasing with their distance to the electrodes. This is often the case for silicon substrates used in electric and photonic integrated circuits. Our method is in good agreement with field simulations, while using this method can significantly reduce the computational complexity and hence calculation times.

11:30 Continuously Tunable Inductorless Phase Shifter Unit Cell Based on NRI-TL Metamaterial

Hörsaal 4

Andrej Lavric[1]; Bostjan Batagelj[1]; Marco Antoniades[2]

[1] University of Ljubljana; [2] Toronto Metropolitan University

A simple method for the design of a continuously tunable phase shifter based on a negative-refractive-index transmission line (NRI-TL) metamaterial without the need for variable inductors is presented. The employed λ/4 transformer solution consists of only three varactor diodes and three corresponding bias resistors, which greatly simplify the design and lower the cost of the phase-shifting stage. A single unit cell of the phase shifter prototype exhibits a total phase shift of 60° over 4 V at 2.4 GHz and a fractional bandwidth of 37% with insertion loss of only 0.5 dB. Some of the drawbacks are also discussed.

11:50 Miniaturized 60 GHz Branch-Line Coupler Using Dual Slow-Wave Techniques in 22-nm FDSOI

Hörsaal 4

Farhan Ahmed; Kaiwen Feng; Quang Huy Le; Thomas Kämpfe
Fraunhofer IPMS, Center Nanoelectronic Technologies

This paper presents a compact 60 GHz branch-line coupler designed in 22-nm FDSOI technology, leveraging dual slow-wave techniques for miniaturization. The design integrates meandered transmission lines with alternate floating shields for the 50-Ohm sections and a bed-of-nails structure with open-ended stubs for the 35-Ohm sections. The coupler occupies an area of 0.049 mm² (1.9 $\lambda_0^2 \times 10^{-3}$) and a fractional bandwidth of 49% as shown by measurements and simulations. It demonstrates a return loss of 26 dB, isolation of -13.3 dB, and insertion loss of -2.7 dB at 56 GHz, with an amplitude imbalance of 1.2 dB and phase imbalance of 3°.

Workshop IHP 2
10:30 - 12:10
Room 301

10:30 IHP's Open Source SG13G2 PDK: Advancing RF and mm-Wave Design

R. 301

Abstract: see first workshop part on page 79

Lunch
12:10 - 13:20
Rooms E01, E03, E05

Keynote 3

13:20 Anritsu: Novel Channel Sounding Techniques for 6G - Near-Field Channel Characterization for Mid-band ELAA Systems

Audimax

Johan Wallblad

6G communication will greatly benefit from using Extremely Large-scale Antenna Arrays (ELAAs) and wide frequency bandwidths enabled by new mid-band spectrum (7-24 GHz) unofficially termed FR3. Deployments of such ELAA systems will be most beneficial in urban crowded areas, such as sports arenas, airports, and other large venues. The distances between User Equipment (UE) and antenna arrays in those scenarios will be relatively short. It is then highly likely that the UE will experience Near-Field (NF) phenomena. MIMO communication can benefit from NF properties, but it is essential to build accurate and realistic NF channel models at the new frequency bands. Thus far, few works have been reported due to the lack of practical ELAA channel sounding systems at FR3.

This presents the work to develop a channel sounder for mid-band ELAA systems, based on a distributed modular Vector Network Analyzer (VNA) and using Virtual Antenna Array (VAA) schemes. Practical measurements were conducted in an indoor scenario using a 720-element virtual Uniform Circular Array ELAA operating at 16-20 GHz. The study reports the presence of NF phenomena such as spherical wavefronts and Spatial Non-Stationary (SNS) effects. The study also reports a method for estimating the multipath parameters, incorporating the NF effects, based on which the Channel Impulse Responses (CIRs) are reconstructed. Those CIRs are shown to be highly similar to the measured channel responses.

Keynote 4

13:50 - 14:20
Audimax
Frank Ellinger

13:50 IHP Solutions: BiCMOS technology for the communication and sensing systems of next generation

Audimax

Corrado Carta

In this keynote, Prof. Corrado Carta will review the role and position of IHP and its SiGe HBTs in the landscape of high-performance microelectronic technologies with several examples of applications, systems and circuits that best leverage the characteristics of those devices. In this context, the talk will provide an overview of IHP offerings to the microwave community, including qualified processes, MPW services and the growing development of open-source tools. Further the upcoming activities in the area of hetero-integration will be presented within the frame of the planned pilot line APECS and the EU Chips Act.

Break

14:20 - 14:40

Communication Systems

14:40 Neural Network-Based Jamming Detection and SINR Estimation for Linearly Modulated Signals

Hörsaal 3

Robin Anger; Marco Krondorf
HTWK Leipzig, Univ. for Applied Science, Germany

Jamming of wireless communication signals is a widely considered problem in performance-critical applications. Jamming often refers to wanted (intentional) or unwanted (accidental) interference which arises systematically and reduces signal to noise ratio (SNR) significantly. Multiple approaches of jamming detection have been carried out in the last decades. Our contribution in this paper is the development of a new combined multi-feature detection approach which is realized by means of neural networks. We evaluated different neural network types concerning their jamming detection and SNR estimation performance. Moreover, we show how to minimize the number of neurons in order to trade off computational complexity and detection performance.

15:00 Low-Power 4 GHz Frequency Synthesizer for WAIC Systems in 22 nm fully-depleted SOI

Hörsaal 3

Enno Boehme[1]; Büsra Tas[1]; Piyush Kumar[2]; Marc Huppmann[1]; Dario Stajic[2]; David Borggreve[1]; Linus Maurer[2]
[1] Fraunhofer EMFT; [2] Universität der Bundeswehr München

A 4 GHz frequency synthesizer based on a fractional-N phase-locked loop (PLL) with a MASH 1-1-1 SDM is presented. The design was implemented in GlobalFoundries' 22 nm FDX (22FDX) process, which is well suited to integrated RF designs in this frequency range, using an active area of ca. 0.25 mm². This frequency synthesizer is intended as a building block for a demonstrator of a wireless intra-aircraft communication (WAIC) system. This paper covers the design architecture as well as simulation and measurement results of the high-performance on-chip signal generator system.

15:20 An Efficiency-Enhanced Electrical Balance Duplexer

Hörsaal 3

Boxun Yan; Ethan Lai; Mau-Chung Frank Chang
University of California, Los Angeles

In this paper, we present an efficiency-enhanced electrical balance duplexer for in-band full duplex transceivers. The proposed electrical balance duplexer eliminates the inherent 3 dB insertion loss of the power amplifier and enables spatial selectivity at the receiver. The circuit and antenna configurations are analyzed and simulated by using full-wave three-dimensional electromagnetic solvers. The proposed electrical balance duplexer leverages the intrinsic orthogonality of waves and the transition between lumped and distributive systems.

15:40 Li2BC: From Visible Light Communication to Ambient RF Backscatter

Hörsaal 3

Kalle Koskinen; Boxuan Xie; Kalle Ruttik; Riku Jäntti
Aalto University

Ambient backscatter communication (AmBC) is a key enabler for the energy-efficient Internet of Things (IoT) that employs existing radio frequency (RF) signals for low-power communication. One open question is how to efficiently send data to the backscatter device (BD) for controlling its operations. Recent research reveals that the ubiquitous presence of configurable light-emitting diodes (LEDs) can leverage such control functionalities by involving visible light communication (VLC). However, existing works only consider relaying the received VLC signals for BD control without storage and processing, which sacrifices configurability and flexibility. In this paper, we propose the Li2BC, a backscatter device (BD) that integrates the VLC receiving, processing, and backscatter modulation functionality. By leveraging a low-power microcontroller, the BD can receive, amplify, demodulate, and store/cache VLC signals. The stored/cached signals are then used for backscatter control. We demonstrate the end-to-end data transmission from LEDs to an RF receiver. The investigations verify that the Li2BC can efficiently receive VLC signals and then use them to control backscatter modulation.

16:00 H-Band Waveguide Filters for Duplex THz Communications

Hörsaal 3

Simon Haussmann[1]; Marc Günter[1]; Axel Tessmann[2]; Ingmar Kallfass[1]

[1] Institute of Robust Power Semiconductor Systems (ILH) - University of Stuttgart;
[2] Fraunhofer Institute for Applied Solid State Physics IAF, Germany

In this paper, we demonstrate the design of H-band waveguide filters for communication purposes. Based on simple design equations, aided by 3D-FEM simulations, we show that with standard microwave H-plane iris filters, we can achieve a waveguide diplexer, covering the whole WR-3.4-band from 220 GHz to 325 GHz and are thus predestined for sub-THz communication links. The design and the applicability for duplex data links is further evaluated in real-time over-the-air communication experiments.

Focus Session Semiconductor Technology

14:40 - 16:20
Room 403
Andreas Mai

14:40 SiGe BiCMOS Wafer-level Packaging and Antenna Integration for sub-THz Applications

R. 403

Matthias Wietstruck; Sebastian Schulze; Patrick Krüger; Thomas Voß; Muhammad Faisal Bashir; Selin Tolunay Wipf; Emre Can Durmaz; Kanaka Joy
IHP Leibniz Institut für innovative Mikroelektronik

This paper demonstrates BiCMOS wafer-level packaging and antenna integration technologies using an advanced Al-Al bonding process. A silicon interposer wafer-level packaging platform is demonstrated using a C2W Al-Al bonding process of a BiCMOS and an interposer test chip. It enables low ohmic interconnections with a bond pad resistance below 30 mΩ which enables ultra-wideband low-loss interconnections based on W2W and C2W Al-Al bonding interconnections. The realized silicon interposer technology is extended with embedded dielectric resonant antennas providing a versatile high performance antenna-in-package integration platform for BiCMOS sub-THz communication, radar and imaging applications.

15:00 530 GHz f_{max} 90 nm SiGe BiCMOS Technology for Sensing and Communication Applications

R. 403

Josef Boeck
Infineon Technologies

This paper reports on Infineon's next generation SiGe BiCMOS technology B12HFC featuring a SiGe HBT with 530 GHz maximum oscillation frequency integrated in a 90 nm CMOS platform. Electrical high-frequency parameters are shown, including uniformity within wafer and lot to lot variation. The features of the process design kit, which enables circuit development, are described. Results on reliability tests for the new technology are given, and the electrical performance of demonstrator circuits for mm-wave applications is presented.

15:20 A Review and Performance Comparison of Key Radar Transceiver Building Blocks at J-Band in IHP SG13G2 and SG13G3 BiCMOS Technologies

R. 403

Batuhan Sutbas; Raqibul Hasan; Ahmed Gadallah; Mohamed Hussein Eissa; Corrado Carta
IHP Leibniz-Institut fur innovative Mikroelektronik

In the past decade, radar and imaging applications have expanded into the terahertz (THz) frequency range, driven by the continuous advancements in semiconductor processing technologies. This article revisits the design of an exemplary transceiver (TRX) integrated circuit (IC) at 256 GHz, which can be cascaded in a daisy chain along its local oscillator (LO) chain in a multiple-input multiple-output (MIMO) scenario. This paper evaluates and reviews the performance of key circuit blocks and their transistor cores implemented in silicon–germanium (SiGe) bipolar complementary metal–oxide–semiconductor (BiCMOS) technologies of IHP toward building the next-generation chipsets in the sub-THz band. An overview of the J-band (220–320 GHz) state-of-the-art low-noise amplifiers (LNAs), power amplifiers (PAs), and frequency multiplier chains (FMCs) implemented in SG13G2 and SG13G3 is presented, where the latter demonstrate unprecedented bandwidth (BW) potential to extreme resolution.

15:40 InP-HBT MMIC for RF Applications: Technology Roadmap and Heterointegration

R. 403

Hady Yacoub; Marko Rausch; Eugen Dischke; Christoph Mangiavillano; Wolfgang Heinrich; Patrick Scheele

Ferdinand-Braun-Institut gGmbH Leibniz-Institut für Höchstfrequenztechnik

InP-HBT monolithic microwave integrated circuits offer a tailored solution for radio frequency applications in the W-, D-band and beyond. The capabilities can be expanded further through heterointegration combining the high-frequency advantages of III–V technology and the maturity and complexity of silicon-integrated technologies such as CMOS and bipolar CMOS.

16:00 Varactors for Integrated RF Circuits in a 130 nm BiCMOS Technology

R. 403

Matteo Elviretti; Andrea Malignaggi; Nicola Pelagalli; Holger Rücker; Luca Menicucci Salamanca; Christian Wipf; Corrado Carta; Andreas Mai

IHP Leibniz-Institut für innovative Mikroelektronik

This paper addresses the optimization of accumulation-mode MOS-type (A-MOS) varactors in a 130 nm BiCMOS technology for applications in voltage-controlled oscillators (VCOs). By optimizing the varactor well doping profile, the tuning gain of the varactor decreased from ~ 3 fF/V· µm² to less than 2 fF/V· µm², while the linear voltage range of the C-V curve increased from 0.8 V to 1.8 V maintaining an overall tuning range larger than 3. The impact of the varactor optimization on VCO performance was studied through circuit simulations, demonstrating a reduction of the phase noise at 32.8 GHz carrier frequency and 1 MHz offset by 4 dB/Hz.

Sensors 1

14:40 A Visible Light FMCW Lidar System Based on LEDs

R. 401

Stephan Kruse; Jan Brockmeier; Tobias Schwabe; J. Christoph Scheytt
Heinz Nixdorf Institute, University of Paderborn

This paper presents a frequency-modulated continuous wave (FMCW) light detection and ranging (lidar) system based on visible light-emitting diodes (LEDs). In the proposed system architecture, the intensity of LEDs is modulated by an FMCW chirp. This paper presents and analyses such an FMCW lidar system. Furthermore, the results of the analysis are validated through initial measurements using an automotive headlight. With an optical modulation amplitude (OMA) of 3.95 dBm, which is much smaller than the optical average power, distances up to 15 meters were measured, demonstrating the potential of the proposed visible light FMCW lidar system.

15:00 Compact Microwave Displacement Sensor

R. 401

Ahmed Nasheed; Fatemeh Habibi; Jan Hesselbarth
University of Stuttgart

A microwave displacement sensor is reported, which is based on the concept of resonator perturbation. A halfwavelength resonator made of a modified stripline, resonating around 6 GHz, is shorted at both ends. The line's center capacitance is variably loaded with a metal, or dielectric, sphere mounted on a plunger. The uniaxial displacement of the plunger translates into resonance frequency variation of, in average, about 0.2 MHz/µm. A peak responsivity of 0.3 MHz/µm is observed. The usable displacement range is more than 1.5 mm. The sensor structure is compact, simple and is designed with the aim of low sensitivity regarding potential movement of the plunger in transverse directions.

15:20 Potentials of Millimeter-Wave Radar Imaging for Non-Invasive Assessment of the Human Spine

R. 401

Ingrid Ullmann[1]; Leonie Richter[2]; Marcel Betsch[3]; Martin Vossiek[1]

[1] Institute of Microwaves and Photonics (LHFT), Friedrich-Alexander-Universität Erlangen-Nürnberg; [2] Friedrich-Alexander-Universität Erlangen-Nürnberg; [3] Department of Orthopaedic and Trauma Surgery, Friedrich-Alexander-Universität Erlangen-Nürnberg

Spine-related diseases such as scoliosis can be diagnosed with X-ray. As a less harmful alternative, optical scanning has been established for spine posture estimation. From a scan of the human's back topology, characteristic points can be extracted to derive the spine's posture. While this modality is less expensive and harmful than X-ray, it comes with the disadvantage that the patient has to undress, which takes time and may cause discomfort. Radar imaging can be an alternative that can capture the back's topology without the necessity to undress. Therefore, in this paper, we investigate the potentials of millimeter-wave radar imaging to capture the surface topology of the back for spine posture estimation. We will present measurement results with a mannequin and compare the results to measurements with an optical reference system.

15:40 High-Temperature Measurements of Moisture Content in Refractory Concrete with Microwave Resonators

R. 401

Daniel Bruhn[1]; Thekla Stein[2]; Wolfgang Taute[1]; Marvin Joiner Ogara[1]; Olaf Krause[2]; Michael Höft[1]

[1] Christian-Albrechts-Universität zu Kiel; [2] Hochschule Koblenz

Refractory concrete materials require a time and energy intensive drying and dehydration process at temperatures up to approximately 600 °C before safe use in industrial applications is possible. To monitor the dehydration process of hydrate phases, a measurement setup based on a high-temperature resistant microwave resonator is presented. The resonator is constructed with conventional, commercially widely available materials and measurements are conducted with inexpensive measurement hardware while allowing for real-time data acquisition during the heating cycle. The resonance frequency f_r and the 3 dB-bandwidth are extracted from measurement data and related to the dehydration process. The measurement results correspond to the loss of evaporated water from the refractory castable material. Ultimately, the temperature stability and reliability of the measurement setup are confirmed.

16:00 Spectrum Analyzer Extenders at 300 GHz Enabling Complex 16-QAM Modulation

R. 401

Javier Martinez-Gil[1]; Veronica Lain-Rubio[1]; Giacomo Ulisse[1]; Oleg Cojocari[1]; Andreas Stohr[2]

[1] ACST GmbH; [2] University Duisburg-Essen

The development of wireless communication systems operating at millimeter wave frequencies has become crucial to meet the rapidly increasing demand for high data rates and low-latency communications. Terahertz (THz) communication links offer unprecedented bandwidth, enabling data rates of several tens to hundreds of gigabits per second (Gbps). This paper demonstrates the transmission and reception of a 16-QAM modulated signal at 300 GHz using spectrum analyzer extenders fully designed, developed and manufactured at ACST GmbH. The spectrum analyzers used in this study were provided by Aaronia AG.

THz Devices 1

14:40 - 16:20
Hörsaal 4
Wolfgang Heinrich

14:40 Gallium-Nitride-Based E-Band Power Detector

Hörsaal 4

Thomas Ufschlag[1]; Benjamin Schoch[1]; Dominik Wrana [1]; Dirk Schwantuschke[2]; Friedbert van Raay[2]; Peter Brückner[2]; Ingmar Kallfass[1]

[1] Institute of Robust Power Semiconductor Systems (ILH), University of Stuttgart, Stuttgart, Germany; [2] Fraunhofer Institute for Applied Solid State Physics (IAF), Germany

This paper presents a Gallium-Nitride-based power detector design, enabling the on-chip monitoring of monolithic integrated high-power Gallium-Nitride power amplifiers in the E-band (71 to 76 GHz). A state-of-the-art sensitivity of 1200 V/W for E-band detectors is achieved by implementing a low-loss matching network, an optimum transistor size, and an ideal loading of the detector. For the first time, modulated power detection is reported and compared to sinusoidal detection in the E-band. The results show the suitability of the presented Gallium-Nitride-based power detector for monitoring the transmit power of wireless communication links in the E-band, targeting high data-rate backhaul applications.

15:00 A 304 to 337 GHz Push-Push Frequency Doubler with 6.8 dBm Pmax using T-Junction Combining in 90 nm SiGe BiCMOS Technology

Hörsaal 4

Sascha Breun; Albert-Marcel Schrotz; Manuel Koch; Norman Franchi; Robert Weigel

Lehrstuhl für Intelligente Technische Elektronik und Systeme, Friedrich-Alexander-Universität Erlangen-Nürnberg

This paper presents a fully integrated 304 GHz to 337 GHz push-push frequency doubler achieving 6.8 dBm peak output power (P_{max}) at 317 GHz for wideband joint communication and sensing (JCAS) applications in the WR03 frequency band. The high output power is achieved by driving the frequency doubler with a 4-way power combined amplifier that achieves a saturated output power of 18 dBm at around 160 GHz. The driving amplifier combines the power of 4 parallel unit cell amplifiers using transmission line based T-junction networks, that are used for matching and low loss in-phase power

combining, simultaneously. A maximum total conversion gain of 28.8 dB from first to second harmonic is achieved with a competitive maximum drain efficiency of 0.47% and fundamental suppression of over 16 dBc within the 3 dB bandwidth. The test structure is fabricated in a 90 nm SiGe BiCMOS technology with f_T/f_{max} of 300 GHz / 500 GHz and consumes an area of 1mm² including pads. Driven by the 4-way driving amplifier, it delivers saturated power in excess of 0 dBm over a bandwidth of 55 GHz from 293 GHz to 348 GHz.

15:20 Hörsaal 4 New Multi-Disk Faraday Rotator Approach for High-Power Radar Duplexers

Katharina Mayer[1]; Alexander Marek[1]; Robert Perkuhn[1]; Jens Klare[1]; John Jelonnek[2]; Manfred Thumm[2]

[1] Fraunhofer FHR (Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR); [2] Karlsruhe Institute of Technology (KIT)

Radar plays a crucial role in the increasingly important field of space situational awareness, essential for the protection of critical space infrastructure. This is achieved through radars for space observation such as the Tracking and Imaging Radar (TIRA) in Germany, and other radars worldwide. As technology progresses, smaller objects in terrestrial orbit require more sensitive high-resolution systems for detection and tracking. To enhance radar signal sensitivity, high power levels and efficient power transmission are essential. Achieving higher spatial resolution necessitates radars with greater bandwidths, which can be more easily realized at higher frequencies. A promising solution for an efficient high-power transmission with a monostatic radar system is a quasi-optical duplexer, with a Faraday rotator as a key component. This contribution presents the theoretical design of a high-power Faraday rotator in the Ka band, considering losses and heat generation. It focuses on the potential for air cooling and a flexible material selection using a novel multi-disk approach, potentially allowing operation at higher power levels than current state-of-the-art Faraday rotators.

15:40 A 300 GHz High-Pass Distributed Amplifier using a Quasi High-Pass Transmission Line Topology

Hörsaal 4

Lukas Gebert[1]; Benjamin Schoch[1]; Thomas Ufschlag[1]; Dominik Wrana[1]; Simon Haussmann[1]; Axel Tessmann[2]; Ingmar Kallfass[1]

[1] Institute of Robust Power Semiconductor Systems (ILH), University of Stuttgart, Germany; [2] IAF-Fraunhofer: Fraunhofer Institute for Applied Solid-State Physics

This paper presents a H-band high-pass distributed amplifier consisting of two cascaded amplifiers, which is used as pre-amplifier to drive subsequent high-power amplifier. The first stage is a high-pass distributed amplifier with four parallel gain cells as driver amplifier. The second stage consists of two parallel high-pass distributed amplifiers, connected using a Wilkinson power dividers. Both stages use RF-grounded shunt stubs at gate-and drain-line in order to design high-pass artificial transmission lines. A 3-dB-bandwidth of more than 80 GHz is achieved with a maximum gain of up to 15 dB and a saturated output power of 3 dBm. The maximum measured power added efficiency exceeds 4.5%. The amplifier is fabricated in a 35 nm InGaAs mHEMT technology.

16:00 PIN Diode-Based Frequency Doubler for D-Band Applications

Hörsaal 4

Isabel Kraus; Herbert Knapp[1]; Nils Pohl[2]

[1] Infineon Technologies AG; [2] Ruhr University Bochum, Germany

This paper explores the potential of pin-diode-like structures for frequency multiplication, focused on doubling, in a well-established commercial SiGe BiCMOS technology. These devices can be manufactured without additional costs by omitting the characteristic implant of the junction varactor layout. Measurement results confirm a pronounced step recovery behavior and the usability of these structures for frequency doubling. A VCO implementation operating around 130 GHz with an output power up to 0 dBm successfully demonstrates the efficient doubling of a fundamental frequency into the D-band.

14:40 - 16:20
Room 204

Workshop Anritsu

14:40 RCS & RIS Measurement Workshop

R. 204

Ferdinand Gerhades
Anritsu

This workshop consists of two parts:

E-Band VNA - RCS Measurement Workshop

The radar cross section (RCS) of a target is the equivalent area seen by a radar. It is the fictitious area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target. The RCS of a target can also be interpreted as a measure of its degree of visibility to a radar. Target RCS measurements are usually performed in the 1 to 20 GHz frequency range, for some smaller objects even up to 40 GHz or even in the millimeter-wave e.g., for passive millimeter-wave identification tags.

This workshop is utilizing a novel E-Band VNA MS46522B-082 for 55 - 92 GHz Over-the-Air (OTA) Applications. The participant will built-up an OTA setup using the VNA and a pair of dielectric high gain antennas to measure the reflectivity of some standard spherical objects and try to calculate the RCS thereof.

PhaseLync - RIS Measurement Workshop

Metamaterials allow the manipulation of their electromagnetic reflection and refraction characteristics. They are key for Reconfigurable Intelligent Surfaces (RIS) concepts and provide a solution to the commonly valid expectation of specular reflections, i.e. they allow arbitrary angles of reflection. The same applies to refraction angles when using transparent metamaterials. Furthermore, shaping the reflected signal (in terms of beam width, for instance) is also possible, as it is changing the polarization planes.

In this workshop, the participant is using a novel distributed VNA concept based on ME7869A up to 43.5 GHz and aims to measure the specular reflection of a TMYTEK active RIS and gaining various Figure of Merit (FOM). The measurements and FOM can be compared using a MS2760A Ultraportable Spectrum Analyzers, one of the smallest formfactors for millimeter-wave measurements up to 170 GHz nowadays.

Coffee Break

16:20 - 17:10
Rooms 101, 103, 105

Radar 2

17:10 - 18:30
Hörsaal 3
Ilona Rolfes

17:10 Combining Run-Length Encoding Preprocessing With Lempel-Ziv-Markov Algorithm to Enhance Compression for Automotive Radar Data

Hörsaal 3

Rainer Rückert[1]; Christian Herglotz[2]; Oliver Sura[1]; Youliy Ninov[3]; André Kaup[4]; Martin Vossiek[1]

[1] Institute of Microwaves and Photonics (LHFT), Friedrich-Alexander-Universität Erlangen-Nürnberg; [2] Brandenburg University of Technology (BTU) Cottbus-Senftenberg; [3] GPP Communication GmbH & Co. KG; [4] Lehrstuhl für Multimediakommunikation und Signalverarbeitung (LMS), Friedrich-Alexander-Universität Erlangen-Nürnberg

The integration of high-resolution radars in vehicles with central processing systems has significantly increased data volume in sensor networks. To address this issue, researchers have investigated radar data compression methods designed to reduce information loss, conserve resources, and improve processing efficiency. These methods include lossy preprocessing and quantization. This paper focuses on a data stream generated by Run-Length Encoding (RLE), which is adapted for complex radar data with a dynamic counter length. Following this, the data stream is further compressed using either the Lempel-Ziv-Markov Algorithm (LZMA) directly or a combination of Huffman coding before LZMA. We compare the compression ratio achieved by RLE alone, RLE with Huffman coding, RLE with LZMA, and RLE with Huffman coding followed by LZMA. Our methods achieve average compression ratios of up to 48500 on actual radar data.

17:30 Radon-Fourier Transform for Timing Correction in Uncoupled Digital Radar Networks

Hörsaal 3

Julian Aguilar; Lukas Paulus; David Werbunat; Alexander Grathwohl; Christian Waldschmidt

Ulm University, Institute of Microwave Engineering

Uncoupled radar networks offer many desired features such as large virtual apertures and flexibility in sensor placement without costly radio frequency (RF) cables. However, they also introduce novel challenges, especially the recovery of coherency between individual radar sensors. The correction of timing errors due to sampling frequency offsets (SFO) between a transmitter's digital-to-analog converter (DAC) and receiver's analog-to-digital converter (ADC) is essential for the coherent processing of uncoupled digital radar network measurements. Systems with different error estimation and correction approaches have been proposed recently, which utilize resampling-based algorithms. However, they are costly to implement, i.e. on an FPGA, and require additional signal processing steps. The herein presented Radon-Fourier Transform (RFT)-based algorithm is capable of directly calculating the corrected radar image without any resampling, negating the downside of additional signal processing steps required after resampling. It is shown that the RFT approach can almost completely restore erroneous radar data, and even outperforms the resampling-based algorithm.

Michael Kretzschmar

17:50 Joint Evaluation of Distributed Sparse Antenna Arrays to Achieve High Angular Resolution in Automotive Radar Networks

Hörsaal 3

Lukas Sigg; Lucas Giroto de Oliveira; Christian Karle; Thomas Zwick; Benjamin Nuss

Karlsruhe Institute of Technology

This paper presents an approach that enables direction-of-arrival estimation on a combined aperture of radar nodes in a radar network, even if large gaps exist between the individual node positions. To facilitate the formation of a combined virtual aperture, a coherent network is required. A method for achieving phase synchronization between the individual sensors is also outlined in this paper. The simulations and measurements presented here demonstrate the feasibility and advantages of such a system. By creating a combined aperture, future requirements for automotive radar sensing, such as higher angular resolution with reduced processing complexity compared to a uniform linear array with the same size and a spacing of $\lambda/2$, can be met.

18:10 Dual-Mode Nonlinear Radar with an Auxiliary Transmitter: Coverage Analysis

Hörsaal 3

Andrei Mogilnikov[1]; Anastasia Lavrenko[1]; Rifat Afroz[2]; Graeme Woodward[2]

[1] University of Twente; [2] University of Canterbury

Nonlinear radar uses passive harmonic tags to detect and track objects in cluttered environments. Being an effective solution against clutter, it is notorious for its low range in relation to transmit power. A novel dual-mode nonlinear radar employs auxiliary transmitters to generate and process harmonic and intermodulation tag returns. This work investigates how this dual-mode operation can be leveraged to increase system coverage.

Sensors 2

17:10 Verification of Hardware Implementation and Evaluation of Target Detection Performance for PMCW against FMCW Radar System

R. 401

Moritz Kahlert[1]; Markus Schmidt[1]; Tai Fei[2]; Claas Tebruegge[1]; Torsten Bertram[3]; Marius Pesavento[4]; Markus Gardill[5]

[1] HELLA GmbH & Co. KGaA; [2] Fachhochschule Dortmund; [3] TU Dortmund; [4] Technische Universität Darmstadt; [5] Brandenburg University of Technology Cottbus-Senftenberg

Frequency-modulated continuous wave (FMCW) is the state-of-the-art modulation scheme in modern automotive radar systems. However, digital modulation schemes, such as phase-modulated continuous wave (PMCW) and orthogonal frequency-division multiplexing (OFDM), have recently attracted increased interest due to various benefits. Until now, assessments of the applicability of PMCW to automotive radar systems have been carried out predominantly in simulation environments. Although simulations provide preliminary estimates, empirical measurements are essential for performance validation. Hardware implementations of PMCW, and therefore, comparative studies between these two modulation schemes remain sparse. This study presents a custom-built single-input single-output (SISO) PMCW radar demonstrator and evaluates its performance against a commercially available FMCW automotive radar evaluation board. The results indicate that the PMCW radar system achieves comparable performance to the FMCW radar system, also demonstrating enhanced target separability.

17:30 Monolithically integrated W-band detector with adjustable sensitivity

R. 401

Adam Rämer[1]; Edoardo Negri[2]; Eugen Dischke[1]; Serguei A. Chevtchenko[1]; Viktor Krozer[1]; Hossein Yazdani[1]; Wolfgang Heinrich[1]

[1] Ferdinand-Braun-Institut Leibniz-Institut gGmbH; [2] Sapienza University of Rome, Italy

In this paper, we present for the first time the design and measurement of our monolithically integrated W-band detector. We show that two mechanisms, the detector operating point and the variation of the antenna base impedance, influence the optical sensitivity. This makes it possible to control the sensitivity across the entire W-band.

17:50 Ethnicity- and Gender-Specific Electromagnetic Power Absorption in Skin Tissues Across 5G/6G Frequencies

R. 401

Sinan Doğusan; Mandana Jalali; Jan Taro Svejda; Daniel Erni

General and Theoretical Electrical Engineering (ATE) Faculty of Engineering, University of Duisburg-Essen

This investigation involves the modelling of skin probes in four different anatomical body regions (abdomen AB, back BC, breast BR, forehead FH) of both genders (male and female) from three ethnic groups (Chinese CH, Korean KR and Turkish TR). Twenty-four different skin probes were modeled by using five different homogeneous skin tissue layers, namely stratum corneum (SC), viable epidermis (E), dermis (D), hypodermis (H) and muscle tissue (M), and comprehensive analyses were performed by exposed to electromagnetic (EM) plane waves in the 5G/6G frequency band (1-300 GHz) using Finite Element Method (FEM) based COMSOL Multiphysics simulation software. The results provide detailed data on the EM power absorbed in each tissue layer (together with the correlated penetration depths of the EM fields in the skin probes) and demonstrate ethnicity- and gender-specific differences in the absorbed power.

18:10 Digitally Reconfigurable Power Detector

R. 401

Prabhav Manchanda; Marcus Knaack; Frank Tost; Cristina Andrei; Matthias Rudolph
Brandenburg Technical University Cottbus-Senftenberg

This paper presents a reconfigurable diode detector operating at 24 GHz, capable of dynamically adjusting its output voltage and linear range through digital control of the load impedance. The variation in load impedance is initially achieved by employing a variable resistor within the baseband amplifier. Subsequently, the same effect is accomplished using a fully digital solution by configuring the internal programmable gain amplifier (PGA) of an analog-to-digital converter (ADC). The detector, the baseband amplifier, and the ADC are fabricated using commercially available components. Experimental results demonstrate that the linear range can be extended significantly by reducing the input impedance of the baseband amplifier, whereas an increase in impedance results in an elevated output voltage. Similar trends are observed when utilizing the PGA within the ADC. The results demonstrate a reconfigurable diode detector that employs digital control to dynamically optimize performance metrics, including output voltage and linear range. This adaptability renders it highly versatile and well-suited for a broad spectrum of modern RF system applications.

17:10 - 18:30
Hörsaal 4
Ivan Ndip

THz Devices 2

17:10 Low Insertion Loss D-Band SP4T Switch using Reverse Saturated SiGe HBTs

Hörsaal 4

Nicolò Moroni; Andrea Malignaggi; Christoph Herold; Corrado Carta
IHP Leibniz-Institut für innovative Mikroelektronik

This paper presents a D-band single-pole four-throw switch designed in a 130 nm SiGe BiCMOS technology adopting a quarter-wave multiple-shunt reverse saturated topology, with the main purpose of being used in broadband and squint-free phased array transceivers. Three distinct cores were included into each branch to achieve high input-output isolation and at the same time improve the operating

bandwidth. The discussed single-pole four-throw switch shows state-of-the-art performances from 110 to 170 GHz in terms of insertion loss, with a minimum of 4.1 dB at 138 GHz including pad losses, and a I/O isolation better than 30 dB across the whole D-band. The power consumption is 12 mW from a 2 V supply, and it occupies an area of 0.88 mm² including pads.

17:30 GaN-Based Single-Ended Resistive Mixer for V-Band (50-70 GHz) Applications

Hörsaal 4

Dhruvin Dhaval Pandya[1]; Cristina Elena Maurette Blasini[2]; Konstantin Kuliabin[2]; Sandrine Wagner[3]; Rüdiger Quay[2]

[1] Infineon Technologies AG; [2] Institute for Sustainable Systems Engineering (INATECH), University of Freiburg; [3] Fraunhofer Institute for Applied Solid State Physics (IAF)

This work presents the first implementation of a down-converting MMIC mixer in a 100 nm AlGaN/GaN HEMT technology designed to operate in the V-band (50 - 70 GHz). A resistive topology is used for higher linearity and smaller footprint. The proposed MMIC mixer occupies an area of 3mm². Further, it features a conversion gain better than -8 dB, and an isolation greater than 12 dB between the LO and RF ports. The input power-related -1 dB compression point is 15 dBm at an input LO power of 20 dBm. The proposed mixer demonstrates over 30% of input RF bandwidth in the V-band and almost 2.5 GHz of IF output bandwidth. Additionally, the MMIC consumes no power due to its resistive nature.

Sven Döring (DML-BY) /Agentur Focus

17:50 Determining GaN HEMT Trap Models from MHz Load-line Measurement — Synthesis and Evaluation

Hörsaal 4

Petros Beleniotis; Cristina Andrei; Ulrich L. Rohde; Matthias Rudolph
Brandenburg University of Technology (BTU), Cottbus, Germany

The modeling of GaN HEMTs is closely associated with pulsed measurements, which are essential for extracting model parameters related to trapping and thermal effects. However, these characterizations are often hindered by high costs and the time-intensive nature of the measurement process. In this paper, we present and evaluate a novel approach for trap model extraction that utilizes MHz load-line measurements. Our analysis includes a comparative study of the measurements and a demonstration of modeling based on the proposed methodology.

18:10 1-bit Digital Phase Shifter Active RIS Element Based on Dual-Input Ka-band LNA in 130 nm SiGe BiCMOS Technology

Hörsaal 4

Giulio Brancali; Roberto Vincenti Gatti; Guendalina Simoncini; Giacomo Schiavolini; Giulia Orecchini; Federico Alimenti
University of Perugia

In this paper a novel 1-bit phase shifter topology based on dual input Low Noise Amplifier (LNA) for Active Reflective Intelligent Surfaces (Active RIS) is presented. The proposed solution is advantageous when the LNA has to be switched between two different radio-frequency (RF) sources. In particular, the Active RIS receiving (RX) patch antenna has two opposite feed points in order to obtain a 0 and 180 degrees phase shifted signals entering the dual input LNA. A 1-bit digital enable (EN) signal is used to select one of the two inputs at a time, making the LNA behaves as pseudo-switch. Experiments were carried out on a fabricated prototype. The reported results show good agreement with simulations, thus validating the LNA operation. The LNA is based on a 130 nm SiGe BiCMOS technology, operating between 20 and 30 GHz with a 13 dB gain and 3 dB noise figure.

Workshop Tactile Internet

17:10 - 18:30
Room 403

17:10 Workshop on Energy-efficient Electronic Systems for the Tactile Internet

R. 403

Jens Wagner; Johannes Partzsch; Krzysztof Nieweglowski; Frank Ellinger
TU Dresden

The Tactile Internet presents unique requirements, especially for electronic systems. Apart from low latency, those systems have to be as small as possible to allow for sensor data gathering on the human body. To make this possible, several research groups joint forces and combined their expertise on analog and digital integrated circuit design and electronic packaging. This allowed for an optimization of components in every domain but also sparked new solutions at the interfaces, making the result more than the sum of its pieces. We are going to present the results of this research, talk about the application within a unique, interdisciplinary environment and give an outlook towards future developments such as energy-autarkic (“zero energy”) or self-supplying systems and the trend towards circular economy.

Conference Dinner

19:15 - 23:15
Löwensaal

Paul Kuchel

Wednesday, 19th of March

08:30 - 10:10	**Amplifiers 2**	Hörsaal 4
08:30 - 10:10	**Focus Session Body Area Communications**	Room 401
08:30 - 10:10	**Focus Session Joint Communication & Sensing**	Room 403
08:30 - 10:10	**Semiconductor and Packaging Technology**	Hörsaal 3
10:10 - 10:40	**Coffee Break**	101, 103, 105
10:40 - 11:10	**Keynote 5: Joel Dunsmore**	Audimax
11:10 - 11:30	**Break**	
11:10 - 13:10	**Poster Session 2**	Room 405
11:30 - 13:10	**Amplifiers 3**	Hörsaal 4
11:30 - 13:10	**Focus Session THz Communication**	Room 403
11:30 - 13:10	**Radar 3**	Hörsaal 3
11:30 - 13:10	**Transmitter**	Room 401
13:10 - 13:20	**Break**	
13:20 - 13:30	**Awards & Closing**	Audimax
13:30 - 14:30	**Lunch**	E01, E03, E05

Amplifiers 2

08:30 - 10:10
Hörsaal 4
Matthias Rudolph

08:30 A V-band Power Amplifier in 22 nm FD-SOI Supporting Instantaneous Broadband Data Transmission at 20 Gb/s

Hörsaal 4

Tsung-Ching Tsai; Ahmet Çağri Ulusoy
Karlsruhe Institute of Technology (KIT)/ Institute of Radio Frequency Engineering and Electronics (IHE)

This paper presents a V-band power amplifier (PA) designed in 22-nm FD-SOI technology, employing a transformer-based current-combining technique for emerging 5G/B5G and satellite communication applications. Operating with a low supply voltage of 0.8 V, the fabricated PA delivers a gain of 21.4 dB and a 3-dB bandwidth of 20.7 GHz. Under large-signal conditions, the PA achieves a saturated output power exceeding 16.5 dBm and a peak power-added efficiency (PAE) of over 20.9% across 42 to 58 GHz. Additionally, the PA supports broadband modulation signals up to 4 GBd, achieving an instantaneous data rate of 20 Gb/s with 32-APSK modulation; at 50 GHz, the PA demonstrates state-of-the-art performance with 12.3 dBm average output power, 9.3% drain efficiency, at an EVM level of -16.2 dB.

08:50 K-Band 27 dB Gain Inverted Doherty Power Amplifier using Real Frequency Technique in GaN Technology

Hörsaal 4

Adrian Arnold; Muh-Dey Wei; Renato Negra
RWTH Aachen University, Germany

This paper presents the design of a K-band inverted Doherty power amplifier (IDPA) in a 0.15 µm Gallium-Nitride on Silicon-Carbide (GaN/SiC) technology. To achieve a wideband characteristic of the matching networks, the Real-Frequency Technique (RFT) is deployed for synthesis of network topologies. The peaking load transformation network (LTN) is synthesised for simultaneous matching and high output impedance to avoid power leakage to the peaking device in

the lower-power region, using the Black-Box Technique. The presented IDPA achieves a saturated output power of 32 dBm with a peak power-added efficiency (PAE) of 41%, 20% PAE at 6 dB output back-off (OBO), and peak gain of 27 dB at 28 GHz in full-electromagnetic (EM) simulation.

09:10 A 120-GHz Sub-6 dB NF and 19 dB Gain Low Noise Amplifier in 22-nm FDSOI

Hörsaal 4

Kaiwen Feng[1]; Quang Huy Le[1]; Thomas Kämpfe[1]; Dietmar Kissinger[2]

[1] Fraunhofer IPMS, Center Nanoelectronic Technologies; [2] Institute of Electronic Devices and Circuits, Ulm University

This paper presents a 96 GHz - 123 GHz 3-stage low-noise amplifier (LNA) design based on transformer matching networks (TMNs) in 22 nm FDSOI technology. The LNA achieves 19 dB measured small signal gain, 5.3 dB of the noise figure (NF) at 120 GHz, the NF remains below 5.8 dB from 110 GHz to 123 GHz. The LNA consumes 31 mW DC power.

09:30 A Low Power BiCMOS UWB LNA with Reduced Chip Area for Sustainable IoT Electronics

Hörsaal 4

Toni Günter Stenzel; Franz Alwin Dürrwald; Naglaa El Agroudy; Frank Ellinger

Dresden University of Technology

A low power, inductor-free, two-stage UWB LNA was designed and fabricated in 130 nm SiGe BiCMOS technology. The proposed cascadation of a common-base and a common-collector stage with negative feedback enables high gain, wideband active matching and adequate linearity, consuming only 2.9 mW. The measured gain S21 is higher than 10.8 dB while the noise figure NF stays below 5.3 dB over the entire frequency range. Including AC coupling capacitors, the total chip area is less than 0.021 mm². Considering the low power and chip area requirements, the presented LNA provides superior performance to enable the next generation of sustainable RF circuits for IoT applications.

09:50 AI-Assisted Complex Load Mismatch Prediction by Mm-Wave Reconfigurable Doherty Power Amplifier and Input/Output Power Sensors

Hörsaal 4

Filippo Svelto; Chenhao Chu; Edward Liu; Hua Wang
ETH Zurich, Switzerland

This paper presents an AI-assisted approach for mm-Wave Doherty Power Amplifiers (PAs) to predict the PA's unknown antenna load mismatches in large-scaled phased arrays using only input/output power sensors. In phased arrays, the antenna inter-element coupling creates a varying complex load (non-50 Ω), i.e. antenna load voltage standing wave ratio (VSWR), which often causes substantial performance degradation of the PAs. We address this challenge by proposing a machine-learning algorithm acting on an existing mm-Wave reconfigurable Doherty PA with only input/output power sensors. We use the Extreme Gradient Boosting (XGBoost) algorithm to predict the VSWR magnitudes and phases of unknown mismatched loads and thus the optimal settings for the PA's main/auxiliary paths' adaptive biasing voltages can be selected to restore its large-signal linearity and efficiency performance. For proof-of-concept, simulation-based experiments are performed on an existing 4-way mm-Wave PA design in a 45 nm CMOS RFSOI process over VSWR magnitude from 1.5:1 to 2.5:1 and VSWR phase over 0° to 360°. Two parallel ML models predict the VSWR magnitude and phase separately, achieving a VSWR magnitude prediction accuracy RMSE (normalized root mean squared error) as 0.003 and VSWR phase prediction RMSE as 5.22.

08:30 - 10:10
Room 401
Robin Augustine

Focus Session Body Area Communications

08:30 Assessing Cardiac Dynamics through Intracardiac RF Sensing for Hemodynamic Monitoring in Pacemakers

R. 401

Ali Khaleghi[1]; Jacob Bergsland[2]; Ilangko Balasingham[2]
[1] NTNU; [2] Oslo University Hospital

This paper examines the use of radiofrequency (RF) channels for hemodynamic monitoring in cardiac pacemakers. It analyzes RF signal variations between intracardiac transceivers in the right ventricle (RV) and right atrium (RA), as well as subcutaneous receivers, to determine their correlation with cardiac dynamics. The study shows that temporal RF signal variations closely align with cardiac rhythm, allowing for the estimation of parameters such as chamber volume, valve behavior, and pressure changes. These results underscore the potential of RF-based sensing as a novel method for real-time cardiac monitoring in pacemaker systems.

08:50 MMSE Pre-emphasis Incorporating Spatial Diversity for Wideband Implant Communications

R. 401

Lijia Liu; Kota Miyazaki; Jianqing Wang
Nagoya Institute of Technology

This study proposes a pre-emphasis technique, implemented using the minimum mean-square error (MMSE) algorithm, to incorporate spatial diversity and improve the bit error rate (BER) performance for wideband implant communications. A three-branch transmit diversity scheme is performed using a numerical human model and miniaturized antennas in simulation. Results confirm that the proposed communication system achieves a high data rate of 20 Mbps across antenna orientations spanning 0 to 180 degrees.

09:10 Harmonic Backscattering and Wireless Power Transfer for Deep In-Body Implantable Wireless Sensors: A Novel Approach

R. 401

Aminolah Hasanvand; Ilangko Balasingham
NTNU - Norwegian University of Science and Technology

The integration of harmonic backscattering and RF (Radio Frequency) wireless power transfer (WPT) technologies offers a new pathway for powering and communicating with deep in-body implantable medical sensors. This work introduces a novel system that addresses the critical challenges of miniaturization, low power consumption, and robust wireless communication in implantable devices. By employing a voltage doubler rectifier and leveraging harmonic modulation, the system harvests RF energy efficiently and transmits data reliably via harmonic backscattering. The approach separates uplink communication frequencies from WPT frequencies, reducing interference, mitigating self-jamming, and significantly enhancing receiver sensitivity. Experimental validation demonstrates reliable data transmission at receiver sensitivity levels as low as -97 dBm, even under deep implantation conditions. The compact design employs low-cost components, enabling battery-free operation while maintaining high performance. This innovative system presents a scalable and practical solution for longer-lasting, and more reliable devices for diagnostics and therapeutic applications.

09:30 From Microwave Measurement to Application: Enhancement of Fat-Intrabody Communication by Advanced Computational Techniques

R. 401

Robin Augustine[1]; Pramod Rangaiah[1]; Pradeep Kumar[2]

[1] Uppsala University; [2] HKBK College of Engineering

Fat-Intra Body Communication (Fat-IBC) leverages the unique dielectric properties of human adipose tissue for low-loss microwave signal propagation. This work presents a comprehensive analysis framework combining interpolation and extrapolation algorithms to predict transmission characteristics (S21) across varying phantom lengths and antenna configurations. Interpolation accurately models intermediate lengths, while extrapolation extends predictions to unmeasured distances up to 100 cm. A software application was developed to integrate these computational models with a user-friendly interface and compatibility with microwave design tools. The results validate the efficiency of Fat-IBC for inbody-to-inbody configurations while highlighting challenges in onbody setups. This study establishes a foundation for optimizing Fat-IBC systems for biomedical and wearable applications.

09:50 Health-care Based on Near Field Inter-body Coupling Communication: Modeling and Analysis of Characteristics

R. 401

Xu Zhang[1]; Yong Song[1]; Maoyuan Li[2]; Ya Zhou[1]; Yu Chen[1]; Meng Zheng[1]; Chang Yang[1]; Yizhu Ma[1]

[1] Beijing Institute of Technology, China; [2] Tokyo Institute of Technology, Tokyo Japan

The Internet of Bodies (IoB) enables short-range, low-power communication for implantable medical devices, presenting significant advantages for leadless pacemakers and defibrillators. Near Field Inter-Body Coupling Communication (NF-IBCC) emerges as a promising approach, offering enhanced data security and reduced power consumption compared to traditional radio frequency (RF) methods. However, a comprehensive understanding of its channel model remains elusive. This study introduces a circuit-based channel model for NF-IBCC, validated through experimental analysis. The model characterizes key factors influencing NF-IBCC, including distance, posture, angle, and height, laying a theoretical foundation for its application in IoB and related healthcare applications.

Focus Session Joint Communication & Sensing

08:30 - 10:10
Room 403
Padmanava Sen

08:30 Polarization-Agile MIMO Antenna Design for Next-Generation mm-Wave Joint Communication and Sensing Applications

R. 403

Muhammad Sajjad Ahmad; Muhammad Umar; Padmanava Sen
Barkhausen-Institut gGmbH

A printed cross-polarized dipole antenna, fed by a balun and placed inside a cylindrical cavity-like fixture, integrated with a dielectric lens is proposed in this work for joint communication and sensing (JC&S) applications. The proposed antenna may switch between horizontal, vertical, and circular polarizations, making it suitable for both communication and radar sensing. The design process and simulation results are presented, showing its potential for use in millimeter-wave and massive multiple-input multiple-output (MIMO) systems that combine communication and sensing.

08:50 MIMO Patch-Dipole Antenna Arrangement for 3D ISAC in 6G-V2X

R. 403

Shahab Ehsanfar[1]; Mojtaba Sohrabi[2]; Klaus Mößner[1]; Dirk Plettemeier[2]
[1] TU Chemnitz; [2] TU Dresden

This paper proposes a MIMO phased antenna array design for 3D integrated sensing and communication (ISAC). Combining patch and dipole antennas, the design enables vertical and horizontal beamforming to support vehicular communication, environmental sensing, and verticaldomain applications such as drone detection. Simulation results demonstrate the system's effectiveness in achieving high directivity, and robust detection capabilities, making it a promising solution for 6G ISAC applications.

09:10 Bistatic Micro-Doppler Analysis of a Vertical Takeoff and Landing (VTOL) Drone in ICAS Framework

R. 403

Heraldo Cesar Alves Costa[1]; Saw James Myint[1]; Carsten Andrich[1]; Sebastian W. Giehl[1]; Dieter Novotny[2]; Julia Beuster[1]; Christian Schneider[1]; Reiner S. Thomä[1]
[1] Technische Universität Ilmenau; [2] AeroDCS Gmbh

Integrated Communication and Sensing (ICAS) is a key technology that enables sensing functionalities within the next-generation mobile communication (6G). Joint design and optimization of both functionalities could allow coexistence, therefore it advances toward joint signal processing and using the same hardware platform and common spectrum. Contributing to ICAS sensing, this paper presents the measurement and analysis of the micro-Doppler signature of Vertical Takeoff and Landing (VTOL) drones. Measurement is performed with an OFDM-like communication signal and bistatic constellation, which is a typical case in ICAS scenarios. This work shows that micro-Doppler signatures can be used to precisely distinguish flight modes, such as take-off, landing, hovering, transition, and cruising.

09:30 Improving Fractional Bandwidth and Isolation Between Tx and Rx Antennas Using EBGs at X-band

R. 403

Nafis Hasnayen; Mehrab Ramzan; Swad Al Nahiyan; Padmanava Sen
Barkhausen Institut

In integrated sensing and communication (ISAC) applications, it is essential to have wide bandwidth and high isolation between transmitting (Tx) and receiving (Rx) antennas considering a full-duplex system. This paper demonstrates improved bandwidth and wideband isolation by employing sub-wavelength passive periodic structures, namely electromagnetic bandgap (EBG) structures at 10 GHz. The fabricated design exhibits a measured bandwidth of 1.89 GHz and a minimum isolation of around 42.4 dB at 0.5 λ_0 separation distance between antennas with the help of the EBG structures. The proposed method can be used as a wideband isolation solution for X-band applications maintaining a small package size. In addition to this, this technique doesn't require active circuits and provides a cost-effective substitute for future 6G ISAC applications.

09:50 Sparse Semantic Encoding for Reduced Data Load in Vision-Position Aided mmWave Beam Prediction

R. 403

Sina Tavakolian[1]; Nhan Nguyen[2]

[1] Center for Wireless Communication - Radio Technologies (CWC-RT), University of Oulu; [2] University of Oulu (UOULU)

To improve beam prediction in complex environments, millimeter-wave (mmWave) communications systems are increasingly using multi-modal sensing, leveraging environmental data from different sources such as visual and position sensors to enhance communications. Although this fusion enables a comprehensive view of the environment, transmitting raw data from a sensing node to the base station (BS) via wireless links incurs significant data overhead, presenting a bottleneck for real-time deployment. This paper presents an efficient machine learning (ML) framework that extracts sparse semantic features from RGB images to reduce data transmission while ensuring robust beam prediction. A custom loss function enforces sparsity in the transmitted features, and the combined sparse and position data are employed for beam prediction via an ML model. Experimental results show that our framework achieves comparable accuracy to more complex models but with a fraction of the computational and transmission costs.

Semiconductor and Packaging Technology

08:30 - 10:10
Hörsaal 3
Kambiz Jamshidi

08:30 Evolution and Optimization of a Low-Cost Coaxial-Waveguide-Transition

Hörsaal 3

Marius Falk; Volker Lücken; Andreas Diewald
Hochschule Trier

This paper investigates the effect of a metallic coating using highly conductive silver paint on previously manufactured low-cost copper and aluminum WR90 coaxial waveguide transition (CWT) prototypes,

based on the manufacturing processes and results. The de-embedding of the prototype with varying numbers of applied layers of silver conductive lacquer, intermediate products, reveals the significant impact of increasing conductivity on transmission parameters. The end product in the form of the silver prototype, with a partially over 95% transmitted performance, is indeed competitive compared to the industrially manufactured WR90 CWT considered here. In conclusion, a further improvement of the transmission parameters can only be achieved through an optimization of the surface and input, that is the reflection parameters.

08:50 Pretreatments for Electroless Silver Plating of D-Band Plastic Rectangular Waveguides

Hörsaal 3

Alexander Quint[1]; Fabian Hochberg[2]; Maximilian Eckl[1]; Andreas Frölich[3]; Thomas Zwick[1]; Akanksha Bhutani[1]

[1] Karlsruhe Institute of Technology (KIT); [2] German Aerospace Center (DLR), Oberpfaffenhofen, Germany.; [3] Horizon Microtechnologies GmbH, Karlsruhe

Electroless silver plating is an easy-to-use method to coat plastics and therefore finds its application in the additive manufacturing of waveguide or other RF components. Depending on the plastic used, a pretreatment of the waveguide component is necessary to ensure a sufficient adhesion of the silver layer on the plastic. Different pretreatments are evaluated for two plastics and analyzed regarding the plateability of the waveguide and its RF performance.

09:10 Indium Bump Flip-Chip Process on Gold-Plated and Laser-Structured Alumina Substrate

Hörsaal 3

Marius Kretschmann[1]; Katarzyna Holc[2]; Arnulf Leuther[2]; Thomas Zwick[1]

[1] Karlsruhe Institute of Technology (KIT); [2] Fraunhofer Institute for Applied Solid State Physics IAF

A flip-chip bonding process of indium bump interconnects (IBI) is presented in this paper. Test structures manufactured using an InGaAs process are assembled onto laser-structured alumina carrier boards plated with a 2 µm thick gold layer. DC measurements and shear force tests are performed to evaluate the electrical and mechanical quality of the interconnects.

09:30
Hörsaal 3

High Linearity and Low Noise Au-Free Ohmic Contact AlGaN/GaN HEMT Using Patterned Ohmic Recess for Ka-Band Applications

Howie Tseng; Ying-Ciao Chen; Yueh-Chin Lin; Edward Yi Chang
National Yang Ming Chiao Tung University

In this study, patterned ohmic recessed AlGaN/GaN high-electron mobility transistors (HEMT) with Au- free ohmic contact metal stack of Ti/Al/Ti/W was developed, and its linearity and microwave noise performance were analyzed for Ka-band application. Under the frequency of 28 GHz, the proposed Au-free ohmic contact device was measured with third output intercept point (OIP3) of 38.95 dBm and minimum noise figure (NFmin) of 1.80 dB. Compared to Au-based device, the proposed Au-free AlGaN/GaN HEMT exhibited superior linearity, which could be attributed to the lowered thermal budget of Au-free ohmic contact. Besides, the Au-free device had slightly inferior but still comparable DC and noise characteristics compared to conventional Au-based device, which could be attributed to the compensation posed by the patterned ohmic recess process. The results showed great potential of Au-free ohmic contact AlGaN/GaN HEMT to be used in high linearity transceiver for Ka-band applications.

Coffee Break | **10:10 - 10:40**
Rooms 101, 103, 105

10:40 - 11:10
Audimax
Dirk Plettemeier

Keynote 5

10:40 Audimax

Keysight: The Evolution of Precision Microwave Measurements: or How I learned to Love the VNA

Joel Dunsmore

In the RF measurement world, Vector Network Analyzer are known for their precision, with specifications often in the milli-dB. This talk will trace the evolution of VNAs from basically a fast power-meter, to today's modern VNA who's capability and accuracy make it the most precise way of measuring everything from power, to noise and even EVM, particularly for 6G applications.

11:10 - 11:30

Break

11:10 - 13:10
Room 405
Dirk Plettemeier

Poster Session 2

11:10 R. 405

Reduced hysteresis and low-frequency 1/f noise in metal insulator graphene diodes for RF & THz rectification

Naveen Kolluru; Christian Tückmantel; Zhuang Miao; Alexander Löwen; Thomas Riedl; Daniel Neumaier

Bergische Universität Wuppertal

In this paper, we discuss the reduction in hysteresis and low-frequency 1/f noise observed by changing the barrier insulator layer in Metal-Insulator-Graphene (MIG) diodes. We observed five orders of

magnitude reduction in hysteresis and two orders of magnitude reduction in 1/f noise at low frequencies when zinc oxide (ZnO) is used as barrier layer in these diodes, while the previously reported MIG diodes based on titanium oxide (TiOx) as barrier layer suffer from large hysteresis, large current drifts and high 1/f noise. This study is a comparison of these key parameters which play an important role in the application of these diodes in THz detection.

11:10 A Flexible Data Set for Radar-based Gesture Recognition

R. 405

Theresa Antes; Elizabeth Bekker; Akanksha Bhutani; Thomas Zwick
Karlsruhe Institute of Technology (KIT)/ Institute of Radio Frequency Engineering and Electronics (IHE)

Gesture recognition is a simple and intuitive way of human-machine interaction that is increasingly used to control devices in a variety of applications. Often, the gestures are captured by a radar sensor due to its flexible operation, robustness to challenging lighting conditions, and high privacy capability. Nonetheless, radar-based data sets to train classification structures are still rare. A broad and flexible data set for radar-based gesture recognition of 7 gestures using a fast chirp frequency-modulated continuous wave (FC-FMCW) radar is presented and made publicly available. A descriptive demonstrator is built up and trained to showcase possible usage. The described data set is made available over RADAR4KIT under a creative common license (CC BY).

11:10 A Thermoelectric Cooler reused as Harvester to Power a 434 MHz Wireless Wakeup Receiver from a 10 K Ambient Temperature Gradient

R. 405

Lucas Ott; Georg Meller; Jens Wagner; Frank Ellinger
Technical University Dresden

This article describes a thermal energy harvesting solution based on a thermoelectric cooler (TEC) or Peltier-element, which is able to power a 434 MHz wakeup receiver (WuRx) solely from harvested heat. The dc current consumption of the WuRx analog frontend and

digital backend together is 788 nA from a 1.5 V supply. Accordingly, the WuRx can be powered via a 1.5 V step-up dc-dc converter from a Peltier-element, which is exposed to a temperature difference of 10 K. The Peltier-element outputs more than 70 mV for currents below 10 mA. The WuRx receives on-off keying (OOK) modulated signals with a bit rate of 10 kbit/s and has an input sensitivity of -95 dBm (code error rate < 10^{-3}). This setup constitutes an example of sustainable electronics in the context of IoT and ongoing networking between humans and machines.

11:10 Blind Maximum Ratio Combining using the Constant Modulus Criterion

R. 405

Constantin Wimmer[1]; Marco Krondorf[1]; Steffen Bittner[2]
[1] HTWK Leipzig; [2] INRADIOS Rohde & Schwarz GmbH

The use of multiple receivers allows the implementation of diversity combining schemes to increase the SNR trough coherent addition of the input signals. Maximum SNR gain is achieved through maximum ratio combining (MRC). This signal combining scheme requires estimation of both channel coefficient and noise power at each individual receiver which is why it is more difficult to implement than other diversity reception schemes. We show that the Constant Modulus Algorithm (CMA) approximates the MRC solution with no further knowledge of the signal at hand and propose a simple receiver design for satellite communication. Simulations and real-live tests demonstrate near-optimal performance of the design even for multi carrier signals and very low SNR.

11:10 Analysis of Impedance Characteristics for Electrically Small Implantable Antennas in Lossy Medium

R. 405

Zhengji Li[1]; Xiao Fang[1]; Chuanjie Zhang[1]; Dirk Plettemeier[2]

[1] Beihang University; [2] Technische Universität Dresden

The design principles of implantable antennas are very different from those in free space. To achieve low reflection coefficients, high radiation and transmission efficiency, the insulation layer between the antenna and the lossy medium is essential. The paper analyzes the variation of wave impedance, especially in human tissues, and

finds that magnetic dipoles are more easily matched to human tissues than electric dipoles for small antennas. In addition, the paper studies the effect of the electrical properties of the insulating layer on antenna matching, and it is shown that the insulation layer with high relative permittivity and low loss is beneficial to reduce reflections and improve the antenna's radiation efficiency. Through theoretical analysis and numerical simulation, the validity of the conclusion is verified, which provides theoretical guidance for designing antennas in lossy medium.

11:10 Compact N-Way Recombining Wilkinson Power Dividers for SatCom Applications

R. 405

Dennis Pfrommer; Christian Waldschmidt; Martin Hitzler
Ulm University, Institute of Microwave Engineering

A number of low-insertion-loss Wilkinson power dividers for the Ka-band are presented. Uneven division ratios are achieved by modifying the traditional Wilkinson divider design with recombination stages. Reducing insertion loss is a key goal to ensure the design of power efficient local oscillator (LO) distribution networks. For the design, a resistor model is investigated in a full-wave EM simulation environment. The average insertion loss from 27 to 31.5 GHz for various dividers ranges from 0.4 dB to 1.1 dB compared to the ideal insertion loss. The designed dividers offer promising performance for the implementation of modern communication and radar systems with complex distribution networks.

11:10 FR4-Based Microstrip Anti-Aliasing Filters for Ultra-High-Speed Analog-to-Digital Converters

R. 405

Christian Matthus; Anton Lorenz; Frank Ellinger
Technische Universität Dresden

In this work, passive low-pass filters implemented with microstrip transmission lines are investigated for their usability in ultra-high-speed analog-to-digital converters. Compared to other works which utilize expensive radio-frequency (RF) specified substrates based on e.g., ceramics, the most-frequently used material for printed circuit boards (PCBs) FR4 is used in this work. The filters were designed using analytical estimations and electro-magnetic field (EM) simulations. The most promising filter structures are high-order Chebyshev

and Legendre type filters. We designed them conventionally and with additional stubs acting as band stop filters to suppress spurious passbands. The filters were physically implemented and measured up to a frequency of 67 GHz and show very good performance with a high stopband attenuation for critical frequencies of more than 45 dB and a high skirt steepness. The insertion losses between 1.8 dB and 2.1 dB are slightly higher than those of the reference filters. On the other hand, the effect of spurious passbands is less severe for FR4. These effects are discussed in detail and a comparison to the more expensive RO4350B-filter counterparts is given.

11:10 A Waveguide-to-Balanced-Line Transition with embedded Balun for mm-Wave Measurement Setups

R. 405

Muhammad Umar[1]; Martin Laabs[2]; Niels Neumann[3]; Dirk Plettemeier[2]
[1] Barkhausen Institut gGmbH; [2] Technische Universität Dresden; [3] TU Clausthal

Differential signaling has been the preferred choice in radio-frequency circuits due to its inherent immunity towards common mode noise and cross-talk. However, the standard lab equipment is available with single-ended coaxial connectors or rectangular waveguide (WR) interface. It makes baluns and WR-to-planar transitions the essential blocks in the measurement setups for chipsets and antennas with differential microstrip line (DMSL) feeds. For this purpose, the authors propose a novel co-design of waveguide transistion and planar balun at 60 GHz on a RF PCB with WR flange interface. The PCB design acts as a balun converting 100 Ω DMSL to 50 Ω single-ended microstrip without involving the flange. Whereas, when the flange is attached to the PCB, it redirects the signal from DMSL to the waveguide, disconnecting the single-ended microstrip port. In this way, a single differential device under test can be tested using both single-ended coaxial and WR lab equipment. In this work, the design as well as validating simulations arepresented at 60 GHz license-free band. To the best of the authors' knowledge, this type of structure has not been previously reported in the literature.

11:10 Resolution and Limitations of a SAR System at Close Range

R. 405

Florian Grabs; Martin Obermaier; Evgeny Zakutin; Martin Laabs; Dirk Plettemeier

Technische Universität Dresden

The concept of a scanning radar imaging system is presented in this work. It discusses the imaging constraints regarding the resolution of the scanned aperture and examines the necessity to calibrate the behavior of the antenna during the measurements. From all analyzed aspects follows, that the achievable resolution of the system is mainly constrained by the wavelength of the used radio frequencies.

11:10 Harmonic mixing using self-oscillating signal of a resonant-tunneling-diode oscillator operating in the 900 GHz range

R. 405

Mingxuan Yang

Tokyo Institute of Technology

We observed a beat signal between the injection signal and the self-oscillating signal of a resonant-tunneling-diode (RTD) oscillator operating at 906 GHz. This was achieved through harmonic mixing utilizing the nonlinearity of the RTD. By the spectra obtained for various injection frequencies, we estimated the harmonic injection locking range without the need for a bulky heterodyne mixer.

11:10 Multifrequency WGM Resonator Approach for Study of DNA Solutions with Reduced Microwave Screening

R. 405

Valeriia Chekubasheva[1]; Valeriia Chekubasheva[2]; Alexey I. Gubin[3]; Alexander Barannik[3]; Dmytro Zhulai[1]; Oleg Glukhov[2]; Nickolay T. Cherpak[3]; Svetlana A. Vitusevich[1]

[1] Forschungszentrum Jülich; [2] Kharkiv National University of Radio Electronics; [3] O.Ya. Usikov Institute for Radiophysics and Electronics NAS of Ukraine

This work presents a new approach for studies of DNA molecules with reduced microwave screening using a developed multifrequency Whispering Gallery Mode resonator technique. The proof-of-principle of the suggested method is demonstrated by utilizing a plastic

layer with a microfluidic channel containing nanoliter volumes of liquid. The authors demonstrate the effectiveness of this method for detecting DNA molecules in frozen samples. The key innovations of the study are considerably reduced losses due to phase transition in DNA solutions with temperature decreasing and the application of a multifrequency approach. Precise measurements of shifts in the resonant frequency and Q-factor changes, simultaneously taken at six frequencies reveal clear investigation of DNA molecules. This approach opens new opportunities for efficient and accurate DNA analysis using microwave sensors in scientific and diagnostic fields.

11:10 Investigating Carboxymethyl Cellulose in Aerosol Jet Printed Microwave Humidity Sensors

R. 405

Madhawa Basnayaka; Kalle Ruttik; Riku Jäntti; Katherine Gallegos Rosas; Caterina Soldano

Aalto University

This study presents passive and chipless humidity sensor to continuously monitor relative humidity (RH). The sensor is constructed on kapton substrates, a C-shaped resonator integrated with meander line structure operates at 5.925 GHz printed with silver nanoparictles (Ag NPs) conducting ink. Eco-friendly, carboxymethyl cellulose (CMC) fabricated in between conducting AgNP lines to monitor RH in slowly changing environment. Both layers are deposited using ultrasonic aerosol jet printer technology. The CMC layer served as an active sensing element, enhancing the microwave resonator's sensitivity and overall performance in detecting humidity. The sensor demonstrates high sensitivity, reaching up to 0.77 MHz/% RH across a humidity range of 47.5% to 90%.

11:10 Highly Efficient WR4 Signal Sources and Transceiver for CW Radar Applications

R. 405

Isabel Kraus; Herbert Knapp[1]; Nils Pohl[2]

[1] Infineon Technologies AG; [2] Ruhr Universität Bochum

This paper presents two fundamental-wave oscillator realizations, a fixed-frequency (V1) and a tunable (V2) option, operating above 200 GHz for monostatic continuous-wave (CW) radar sensing. Fabricated in a 90 nm SiGe BiCMOS process, the oscillators achieve high

output power and good efficiency. V1 operates at 202.5 GHz with an output power of 4.9 dBm and a DC-to-RF efficiency of 3.68%. V2 tunes over a 2.8 GHz range around 228.8 GHz with an output power of 4.5 dBm and a DC-to-RF efficiency of 3.36%. Based on both oscillator versions, monostatic I/Q radar transceivers were designed. Precise Doppler radar measurements were conducted successfully up to 150°C chip temperature which demonstrates the capability for robust fundamental-wave signal sources even at high temperatures.

11:10 Power calibration methods for frequency extenders aided modulated measurements at sub-THz/THz

R. 405

Sumit Singh[1]; Piyaphat Phukphan[1]; Timo Rahkonen[2]; Aarno Pärssinen[1]; Marko E. Leinonen[1]

[1] Center for Wireless Communication, University of Oulu; [2] Circuits and Systems Research Unit, University of Oulu

6G technologies are aiming at large absolute bandwidth available at sub-THz/THz frequency ranges for ultrahigh speed wireless communication. State-of-the-art measurement instruments are aided by the frequency extenders to facilitate the extensive on-chip RF characterization of the radio frequency integrated circuits. Unlike millimeter wave measurements, sub- THz/THz on-chip measurements involve the cascaded connections of several RF laboratory components. This requires extensive characterization of the measurement setup to de-embed the effect of the measurement setup from the actual measurement of the device under test. This work highlights the challenge associated with power calibration of the measurement setup for the modulated signal measurement at sub-THz/THz frequency range. Additionally, methods to measure absolute power level and estimate the local oscillator (LO) leakage from frequency upconverter are discussed.

11:10 A Varactor-Based LC-Resonant 3.6GHz LNA for 5G Base Station Applications

R. 405

Vaibhav Choudhary; Sankaran Aniruddhan

Indian Institute of Technology Madras

This research paper introduces a high-gain differential CMOS Low Noise Amplifier (LNA) with a varactor tuned LC-tank at the drain to

reduce process-related variations in resonance frequencies with minimal impact on gain and IIP3. The LNA is designed and fabricated in a 65 nm TSMC CMOS technology and employs a two-stage cascoded differential amplifier topology, with on-chip baluns at the input and output of the chip. Measurements on a chip-on-board bonded die displays a gain of 20.1 dB, accompanied by a power consumption of 24.8 mW from a 1 V supply voltage. The noise figure of the LNA is 5.7 dB and the IIP3 is -12 dBm, showing reasonably good match with postlayout simulations.

11:10 A Dual-Band Frequency Selective Surface Design for Enhanced Spatial Filtering in C-Band

R. 405

Sohaib Yaqoob Chaudhry; Jamal Haider; Hussnain Mohiud Din
National University of Sciences and Technology (NUST)

This paper presents the design of a cost-effective, dual-band frequency selective surface (FSS) operating in the C-band utilizing an FR4 substrate. The proposed FSS is engineered to achieve closely spaced frequency responses and is optimized for wide-angle incidence and polarization insensitivity, making it suitable for various practical applications. The designed FSS resonates at 6.9 GHz and 7.5 GHz with bandwidths of 300 MHz and 200 MHz, respectively, targeting a frequency range used in satellite communication systems.

11:30 - 13:10
Hörsaal 4
Corrado Carta

Amplifiers 3

11:30 A 5G FR1 43.5 dBm GaN Hybrid Doherty Power Amplifier with Dynamic Auxiliary Gate Voltage for Enhanced Gain at Saturation

Hörsaal 4

Abdolhamid Noori[1]; Jorge Julian Moreno Rubio[1]; Christian Fager[2]; Gregor Lasser[2]
[1] Silicon Austria Labs GmbH, Austria; [2] Chalmers University of Technology

This paper presents a dynamic gate bias approach to improve the linearity of a Doherty Power Amplifier (DPA) designed for 5G FR1 app-

lications, utilizing Gallium Nitride transistors. The amplifier adopts a hybrid implementation on a printed circuit board, integrating transmission lines and lumped discrete elements to optimize performance. Although the Doherty architecture is known for its efficiency under back-off conditions, it faces challenges like gain compression at saturation of the main amplifier. To address this, dynamic gate biasing enhances linearity and mitigates gain compression. The DPA is fabricated on a Taconic RF-35 substrate with a dielectric constant of 3.5. The amplifier's performance is evaluated through simulations and measurements. Key metrics, including gain, efficiency, and output power, are assessed for both DPA with standard gate bias and DPA with DGB for the auxiliary amplifier. Measurement results show a peak drain efficiency of 55%, output power of 43.5 dBm, average gain of 13 dB, and a 2 dB improvement in gain compression with the DGB approach. These outcomes confirm the DPA's suitability for high-linearity, high-efficiency 5G FR1 applications.

11:50 Broadband and Compact 112 Gbit/s Transimpedance Amplifier in a SiGe Copper Backend Technology

Hörsaal 4

Festim Iseini; Andrea Malignaggi; Falk Korndörfer; Corrado Carta; Gerhard Kahmen

IHP Leibniz-Institut für innovative Mikroelektronik

In this paper, an ultra broadband and compact transimpedance amplifier fabricated in the novel high performance 130 nm IHP SG13G3 copper backend technology, featuring f_T/f_{max} of 470 / 650 GHz, is presented. The amplifier is composed of three stages, an input stage with a standard shunt-shunt feedback topology, used to obtain a compromise between speed, noise and gain, a current-steering variable gain amplifier and a cascode, used as a buffer, at the output. Inductive peaking techniques have been employed to increase the bandwidth and flatten the frequency response, while degeneration networks have been used to improve the linearity of the circuit. Measurement results show that the proposed design has a low frequency transimpedance gain of 50 dBΩ, a 28.1 pA/√Hz at 115 GHz of noise current density and a 3 dB bandwidth of more than 115 GHz, along with a total harmonic distortion at 1 dB compression point of 4%, in band group delay variation of ±1.5 ps and an overall power dissipation of 165 mW at nominal conditions. Time domain measurements show operation up to 112 Gbps non-return-to-zero.

12:10 A D-band 23.5 dB High Gain 0.8 V Low-Power Transformer Matched LNA in 22 nm FDSOI CMOS

Hörsaal 4

Peter Wagner[1]; Aditya Gupta[1]; Deniz Tas[2]; Marco Dietz[2]; Amelie Hagelauer[3]

[1] Technical University of Munich; [2] Fraunhofer EMFT; [3] Technical University of Munich & Fraunhofer EMFT

This work presents a D-band fully differential four-stage common-source low noise amplifier (LNA). The design operates in 110 GHz-140 GHz frequency region, with a 22.4 GHz 3-dB bandwidth, achieving a peak gain of 23.5 dB at 115 GHz with a DC power consumption of 52 mW. It has a noise figure of 7.5 dB at 140 GHz and 8.2 dB at 120 GHz. To allow broadband simultaneous matching and biasing, transformer-based interstage matching has been utilized. The design also utilizes back-gate biasing to further increase the linearity and gain of the amplifier.

12:30 Study of Hybrid Schottky – Ohmic Source and Drain AlGaN/GaN HEMTs for Low Noise Application

Hörsaal 4

Nengda Li; Hohsin Chang; Chihhao Yang; Yueh-Chin Lin; Edwardyi Chang
National Yang Ming Chiao Tung University

In this study, AlGaN/GaN high-electron mobility transistors (HEMTs) with hybrid Schottky-ohmic source and drain structures were fabricated for low noise applications. The transconductance was improved due to the Schottky metal extension. Furthermore, the device achieved higher f_T and f_{max}, reaching 72.6 GHz and 162 GHz, with lower extracted parasitic resistance. At 28 GHz, the device demonstrated excellent NF_{min} of 1.51 dB. These results confirm that the AlGaN/GaN HEMT with a hybrid source and drain offers great potential for outstanding low noise performance in Ka-band applications.

Focus Session THz Communications

11:30 - 13:10
Room 403
Meik Dörpinghaus

11:30 Array-Fed RIS: Validation of Friis-Based Modeling Using Full-Wave Simulations

R. 403

Krishan Kumar Tiwari[1]; Thomas Flisgen[2]; Wolfgang Heinrich[2]; Giuseppe Caire[1]
[1] Technische Universität Berlin; [2] Ferdinand Braun Institute

Space-fed large antenna arrays offer superior efficiency, simplicity, and reductions in size, weight, power, and cost (SWaP-C) compared to constrained-feed systems. Historically, horn antennas have been used for space feeding, but they suffer from limitations such as bulky designs, low aperture efficiency (50%), and restricted degrees of freedom at the continuous aperture. In contrast, planar patch arrays achieve significantly higher aperture efficiency (>90%) due to their more uniform aperture distribution, reduced weight, and increased degrees of freedom from the discretized aperture. Building on these advantages, we proposed an array-fed Reflective Intelligent Surface (RIS) system, where an active multi-antenna feeder (AMAF) optimizes

power transfer by aligning with the principal eigenmode of the AMAF-RIS propagation matrix T. While our previous studies relied on the Friis transmission formula for system modeling, we now validate this approach through full-wave simulations in CST Microwave Studio®. By comparing the Friis-based matrix, T_{Friis}, with the full-wave solution, $T_{full.wave}$, we validate the relevance of the Friis-based modeling.

11:50 Large Fractional Bandwidth D-Band Power Amplifier for 6G Communications in 130-nm SiGe BiCMOS Technology

R. 403

Mohammed Ali [1]; Thiemo Herbel[1]; Goran Panic[2]; Dietmar Kissinger[1]
[1] Ulm University; [2] IHP Leibniz-Institut für innovative Mikroelektronik

This paper presents two wideband power amplifiers (PA) for future 6G wireless communications. One-way and two-way stagger-tuned PAs are designed and fabricated in 130-nm SiGe BiCMOS technology with heterojunction bipolar transistors (HBT) with f_T/f_{max} of 300 GHz and 450 GHz, respectively. Large-signal wideband operation of the one-way PA is achieved by a transformer-based output power matching. A high magnetic coupling power combining transformer and balun is utilized for the output power matching of the two-way PA leading to wideband yet low-loss matching. The one-way PA covers the entire D-band in terms of 3-dB bandwidth. It achieves an output P1dB of 11 dBm and a maximum PAE of 5%. The two-way PA has a 3-dB bandwidth of 48 GHz centered around 140 GHz. It delivers linear power up to 13 dBm. The one- and two-way PAs show a gain of 30 dB and 22 dB, and their cores occupy a silicon area of 0.145 mm² and 0.2 mm², respectively.

12:10 Design of a Scannable Multi-Lens Quasi-Optical System for THz Near-Field Backhaul Communication

R. 403

Huasheng Zhang; Alexandros Bechrakis Triantafyllos; Nuria Llombart Juan; Maria Alonso del Pino
Delft University of Technology

Radiative near-field links have gained noticeable interests recently for high-data-rate wireless communication. Unlike far-field links, ne-

ar-field links can have negligible path loss within hundreds of meters for electrically large antennas at high frequencies. In this work, we propose a multi-lens quasi-optical (QO) system for 100-m near-field backhaul communication at H-band. The QO system is designed with compact size (aspect ratio of 1.3:1) and high coupling efficiency of 82%. Moreover, the rotation of an auxiliary lens realizes beam scanning for the link alignment. The scan range is in the order of 1 m with less than 2 dB scanning coupling loss and scanning magnification of 14.5:1.

12:30 Improving Power Amplifier Efficiency of Zero-Crossing Modulation at Sub-THz Frequencies

R. 403

Florian Gast; Kejian Xu; Meik Dörpinghaus; Gerhard Fettweis
Technische Universität Dresden

Utilizing the vast bandwidths available in the THz and sub-THz bands poses significant challenges, particularly with regard to the power consumption of the analog front end. For example, the analog-to-digital converter (ADC) power consumption is suspected to increase significantly due to the increase in bandwidth. As shown in prior work, reducing the ADC's amplitude resolution down to 1-bit and using tailored modulation schemes, such as zero-crossing modulation (ZXM), can partly mitigate this issue. However, the power amplifier (PA) at the transmitter typically dominates the overall power consumption. Thus, in this work we evaluate the PA efficiency of ZXM under non-linear distortions and propose two techniques to enhance PA efficiency: i) offsetting the in-phase and quadrature components by half a symbol period, and ii) maximizing output power by allowing strong distortions. Our results demonstrate that combining these approaches achieves high amplification efficiency and leads to performance gains in terms of symbol error rate.

12:50 Waveguide fed PCB-based Broadband Antenna Array for 6G Sub-THz Wireless Communication

R. 403

Alexander Gäbler; Uwe Maaß; Ivan Ndip
Fraunhofer Institut für Zuverlässigkeit und Mikrointegration (IZM)

In this work, the design and measurement of a differentially fed 4x1 D-band antenna array is demonstrated. It features a very high bandwidth of 15 GHz and utilizes a differential line feeding concept based

on a rectangular WR5 waveguide. This simplifies the measurement procedure as it can be loosely attached at the back side of the RF PCB module. To investigate the applicability towards advanced packaging concepts for 6G applications, special care had been taken to reduce the required footprint within the PCB below a wavelength for this transition.

11:30 - 13:10
Hörsaal 3
Tobias Weber

Radar 3

11:30 Automotive Radar Processing with Neuromorphic Hardware: A Case Study from the KI-ASIC Project

Hörsaal 3

Bernhard Vogginger[1]; Chen Liu[1]; Felix Kreutz[2]; Florian Kelber[1]; Seifeddine Saadani[3]; Klaus Knobloch[2]; Alfred Höß[3]; Cyprian Grassmann[4]; Christian Mayr[1]

[1] Technische Universität Dresden; [2] Infineon Technologies Dresden GmbH & Co. KG; [3] OTH Amberg-Weiden; [4] Infineon Technologies AG

Radar sensors play an essential role for robust automated driving. As more and more radar sensors with increased numbers of transmitter and receiver channels are integrated into cars, the compute load for radar signal processing increases, also because AI models are increasingly used. To counteract the associated rising energy demand, neuromorphic hardware that realizes brain-inspired spiking neural networks in silicon may be used for energy-efficient radar signal processing. Here, we show a case study from the German KI-ASIC project evaluating the use of the SpiNNaker2 neuromorphic chip for automotive radar processing. First, we implement three different variants of the CA-CFAR algorithm (in software, as convolutional network, as spiking neural network) on the SpiNNaker2 chip and compare them regarding latency, energy and memory usage. Second, we propose and implement a pipeline for radar object tracking and classification on a test car with radar sensor, neuromorphic chip and conventional computer as middleware. This work presents by far the most elaborated approach for automotive radar processing with neuromorphic hardware and provides useful insights for future work.

11:50 Functional Testing of Radar Based ADAS/AD Along the Vehicle Life Cycle

Hörsaal 3

Andreas Himmler
dSPACE GmbH

It is essential to ensure the functional safety of increasingly complex driver assistance systems and systems for autonomous driving (ADAS/AD) over the entire life cycle of a vehicle. After the development phase of a vehicle, its homologation must also be considered, as well as end-of-line testing and regular testing of individual vehicles in the field. Given the importance of automotive radars for ADAS/AD, efficient, safe and reproducible test methods are required for the mentioned test cases. Based on regulatory and technical requirements, this paper presents industry proven solutions whose suitability has been shown in international projects.

12:10 CitRad: A Low-Cost Open-Source Citizen Science Radar System to Democratize Urban Traffic Monitoring

Hörsaal 3

Nanu Tobias Frechen[1]; Marcus Knaack[2]; Markus Gardill[2]
[1] FabLab Cottbus e.V.; [2] Brandenburg University of Technology Cottbus-Senftenberg

Urban traffic monitoring is critical for addressing congestion, speeding, and safety concerns in rapidly urbanizing areas. This paper presents CitRad, a low-cost, open-source Doppler radar system designed for citizen science applications, enabling communities to collect and analyze traffic data independently. The system employs commercially available components, such as a 24 GHz Doppler radar module and the Teensy 4.0 microprocessor, ensuring affordability and ease of assembly. Key features include a dynamic noise floor adaptation for robust target detection. Initial measurement campaigns demonstrated the system's ability to accurately monitor traffic speeds, vehicle lengths, and passing distances, as well as detect specific patterns such as pedestrian and cyclist movements.

12:30 Aperture Efficiency of Active and Passive Radar Targets in Cluttered Environments

Hörsaal 3

Simon Heining[1]; Reinhard Feger[1]; Christoph Wagner[2]; Andreas Stelzer[1]

[1] Johannes Kepler University Linz; [2] Silicon Austria Labs GmbH, Austria

Calibration and verification of radar systems usually requires well-defined targets to calibrate and to evaluate the system capabilities. This paper compares active and passive radar reflectors and their field of application. Theoretical considerations regarding the aperture efficiency are made and compared over frequency. Wavelength and radial resolution are found to be a key factor for surrounding clutter levels. It is shown that for single-digit GHz, active reflectors have advantages compared to passive structures. In contrast, passive targets can be better suited for higher frequencies that are used in automotive bands due to technical simplicity and sufficient radar-cross-section.

11:30 - 13:10
Room 401
Nils Pohl

Transmitter

11:30 Compact and Broadband Up and Down Conversion Mixers for Frequency Interleaving Systems

R. 401

Christoph Herold[1]; Mykyta-Illia Kravchenko[1]; Andrea Malignaggi[2]; Corrado Carta[2]

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This paper presents broadband up and down conversion mixers fabricated in 130 nm SiGe technology. The fully differential design is optimized for very small area occupation and low-power consumption to be scaled to multiple up and down converters for frequency interleaving systems. The mixers can be driven by local oscillator frequencies between 10 and 25 GHz with a radio frequency bandwidth of 2.5 GHz. The corresponding RF signals range from 7.5 to 27.5 GHz. The mixers are designed in a broadband fashion, avoiding the use of matching networks, expensive in terms of both area

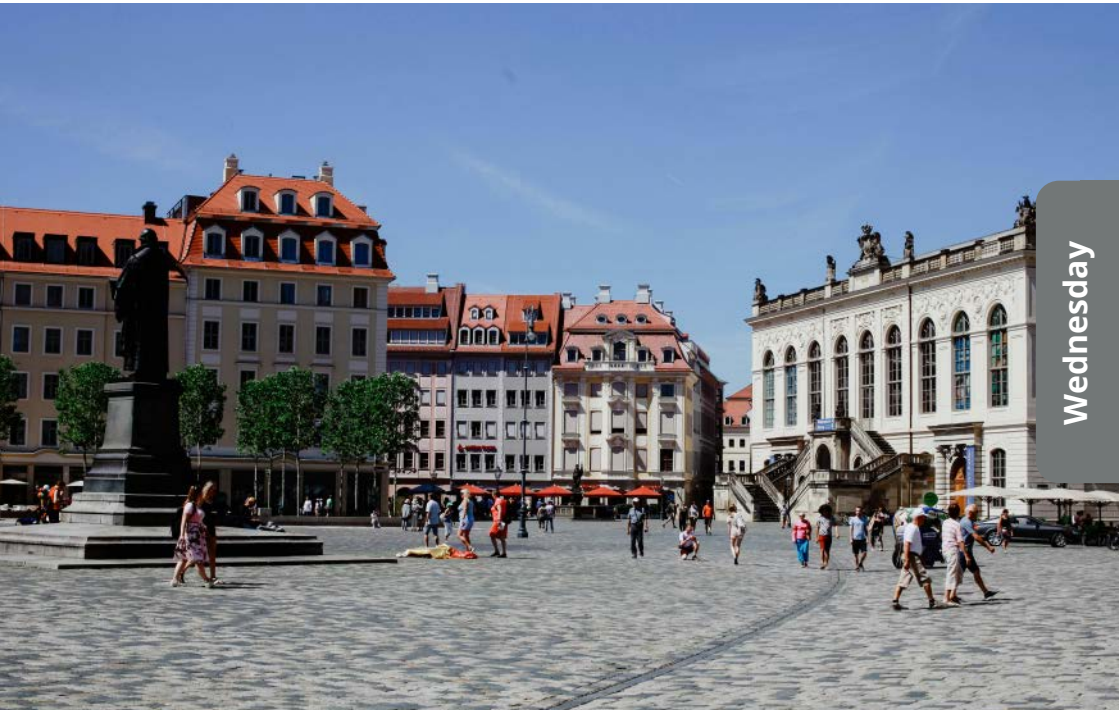
occupation and bandwidth, and include input and output buffers for allowing measurement in a 50 Ω environment. With an active area size of 0.012 mm², both proposed mixers occupy a silicon area which is, to the best of the authors' knowledge, one order of magnitude smaller when compared to the state-of-the-art.

11:50 A Compact Broadband Differential 20-120 GHz Amplifier in a 130-nm SiGe BiCMOS Technology

R. 401

Thiemo Herbel; Dietmar Kissinger
Ulm University

In this paper the design and measurement of a compact broadband differential amplifier are presented. The amplifier is based on an optimized single-stage cascode topology and is highly compact with an active chip area of around 0.02 mm². The circuit consumes 53 mW of DC power from a single 3 V supply. The amplifier is fabricated in a 130-nm SiGe BiCMOS HBT technology with f_T/f_{max} of 350/450 GHz and achieves a small-signal gain of 10 dB and a group delay variation of ±2 ps in the targeted frequency range of 20-120 GHz. Large signal measurements show a fairly constant output 1-dB compression point of around 2 dBm.



12:10 Low and Stable Phase Noise W-Band Capacitive Cross Coupled VCO across tuning range in 90 nm SiGe BiCMOS Technology

R. 401

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A single-core capacitive cross-coupled VCO with a push-push architecture is implemented in 90 nm SiGe BiCMOS technology for high-performance automotive radar applications. The implemented VCO achieved a measured tuning range from 89.9 GHz to 95.4 GHz with a best phase noise of -104.8 dBc/Hz at 1 MHz offset frequency at 25 °C. This is the record value of phase noise achieved for a single core VCO at the mentioned operating frequency range, according to the best knowledge of the authors. The VCO has a stable phase noise with a variation of approximately 1 dBc/Hz across the complete tuning range. Optimizing the VCO current setting also reduces the phase noise variation across temperatures. Additionally, the VCO has achieved excellent supply-pushing performance with 30 MHz/V. The VCO test chip consumes a current of 85 mA, whereas the VCO core needs a current of 23 mA with a single supply of 3.3 V.

12:30 100 GS/s Equivalent Time Sampling Receiver for UWB Radar Applications

R. 401

Marco Mütze; Petr Schaffer; Armin Bakkal; Michael Bärhold; João Vítor Possamai de Menezes; Peter Birkholz; Dirk Plettemeier
Technische Universität Dresden

This paper presents the design of an ultra-wideband (UWB) sub-nanosecond equivalent time sampling (ETS) receiver. It has been developed as a part of a novel silent speech radar application working at frequencies between 500 MHz and 5 GHz. The system is based on commercial-off-the-shelf (COTS) components such as a programmable delay chip (PDC), track and hold amplifier (THA) and an analog to digital converter (ADC). The receiver system has been fabricated on PCB, optimized and tested. The resulting system accepts a LVPECL sampling clock up to 250 MHz and features an analog input bandwidth of 5 GHz and an equivalent sampling rate of up to 100 GS/s.

12:50 A 4-bit 40 GS/s Power Efficient DAC for 6G Communication Systems

R. 401

Ahmed Elsayed; Philip Ostrovsky; Corrado Carta
IHP GmbH - Leibniz Institute for High Performance Microelectronics

This paper presents a power-efficient 40-GBaud digital-to-analog converter (DAC), with a design approach focused on selecting an optimal bias-current to minimize power consumption while targeting a specific bandwidth. A 4-bit DAC has been fabricated in a 130 nm SiGe BICMOS process and operates at a sampling rate of 40 GS/s. This makes it suitable for high-speed modulation schemes such as 64-QAM and 16-QAM, as well as PAM-8. The circuit has been characterized across a range of supply voltages. With a total power consumption of 76 mW, at a 2.3 V supply voltage, the circuit achieved an energy efficiency of 0.63 pJ/bit; to the best knowledge of the authors, this is the best reported energy efficiency for PAM-8 modulators.

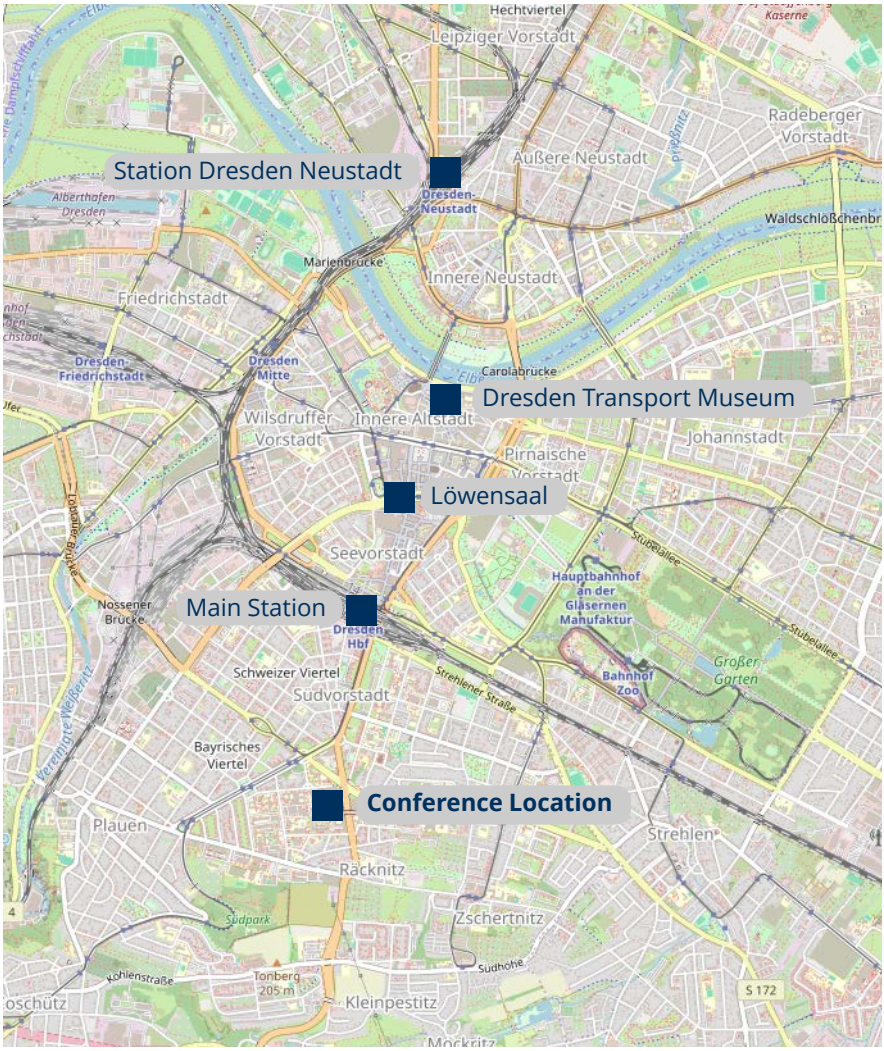
Break 13:10 - 13:20

Awards & Closing 13:20 - 13:30 Audimax

Lunch 13:30 - 14:30 Rooms E01, E03, E05

Dresden - Baroque Beauty

Dresden, often called "Elbflorenz," enchants visitors with its unique blend of history, art, and nature. A short trip takes you past the magnificent Frauenkirche, the impressive Zwinger, and the renowned Semper Opera House. A walk along the Brühl's Terrace offers stunning views of the Elbe, while the lively Dresden Neustadt invites you to relax in charming cafés and explore local galleries. Whether enjoying world-class art at the State Art Collections or venturing into the picturesque Saxon Switzerland, Dresden captivates with its diversity and charm.



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