Program for *13th European Conference on Antennas and Propagation (EUCAP 2019)*

Time	Oral Sessions: S1 - Krakow	Oral Sessions: S2 – Warszawa	Oral Sessions: S3-A – Gdansk	Oral Sessions: S3-B - Wroclaw	Oral Sessions: S4-A - Poznan	Oral Sessions: S4-B - Lublin	Oral Sessions: S4-C - Kielce	Oral Sessions: S4-D - Bytom	Oral Sessions: G1-Gniezno	Oral Sessions: G2-Opole	Oral Sessions: A2-Ustka	Oral Sessions: A1 - Gdynia	Poster Sessions: P1 - Odra	Poster Sessions: P2 - Wisla	Poster Sessions: P3 - Warta
Monday, April 1															
09:00-10:00	Opening: *Opening Session*														
10:00-10:40	IK_01 Mo_1: *IK_01 Invited Keynote 1*														
11:10-12:30	IK_02 Mo_2&3: *IK_02 Invited Keynote 2&3*														
14:00-18:30	CS48 mm-Wave GAP Wave Techn: *CS48 Integration and New Applications of mm-Wave GAP Wave Technology*	CS12 Reflect & Transmitarray: *CS12 Reflectarray and Transmitarray Antennas for Emerging Applications*	CS22 Reconf Ant: *CS22 Reconfigurable Antennas for Compact Devices*	CS14 Periodic Structures Higher Symm: *CS14 Periodic Structures with Higher Symmetries*	CS44 Propagat in Rem Sensing: *CS44 Propagation Aspects in Remote Sensing*	CS36 Prop Ch Veh-to-X: *CS36 Propagation Channels for Wide-Sense Vehicle-to-X Communications*	CS29 Small Antenna Design: *CS29 Small Antenna Designing Methods and Measurement*	CS10 Snowpack monitoring: *CS10 Microwave techniques, modelling, systems, and antennas for snowpack monitoring and snow-related applications*	CS24 Arrays for 5G: *CS24 Antenna Arrays for 5G and Beyond*	CS19 COST CA15104 (IRACON): BAN: *CS19 COST session CA15104 (IRACON): Measurements and Simulations in Channel Modelling in Wireless Body Area Network*	CS27 COST session CA17115 (MyWAVE): *CS27 COST session CA17115 (MyWAVE): Advancements in Electromagnetic Hyperthermic Technologies and Dielectric and Thermal properties of tissues*				
16:30-18:30	CS21 IET/AMTA: 5G and Beyond: *CS21 IET/AMTA Session: Trends and Measurement Challenges for 5G and Beyond*				CS17 Ground Terminal Sat Comm: *CS17 Ground terminal needs and technologies for broadband satellite communications*			CS46 GPR: *CS46 Theoretical, Algorithmic, and Experimental Advances in GPR*	CS32 Transformation Optics: *CS32 Transformation Optics for Antenna Design*	CS43 Array Ant Design: *CS43 Array Antenna Design*					
Tuesday, April 2															
08:40-12:30	MT_A01 Antenna Theory: *MT_A01 Antenna theory, computational and numerical techniques*	CS23 Future Space Missions: *CS23 Antenna needs and solutions for future Space missions*	CS1 Unconv Techn Inv Scatt: *CS1 Unconventional techniques and applications for inverse scattering problems*	F_M04 Anal & Proc Ant Meas Data: *F_M04 Effective Analysis and Processing of Antenna Measurement Data*	C_M01 MIMO & OTA testing: *C_M01 MIMO and OTA testing*	CS28 Channel Modelling Railway Env 5G: *CS28 Channel modelling in railway environments for 5G applications*	CS13 Ant on IoT: *CS13 Antennas on IoT applications*	R_M01 Radar Scattering: *R_M01 Radar Scattering Measurement and Calibration Techniques*	H_A02 MM SubMM THz: *H_A02 Millimeter, Sub-millimeter and TeraHertz Antennas*	W_A02 Arrays Ant Wireless: *W_A02 Arrays Antenna for Wireless Networks*	CS26 Micr Sensors Biomed Apps: *CS26 Microwave Sensors for Biomedical Applications*				
10:50-12:30	CS9 Aper Array Radio Telesc: *CS9 Antennas for Aperture Array Radio Telescopes*			F_M01 Test ranges: *F_M01 Near-field, far-field, compact and RCS test ranges*	C_P01 Prop for vehicular comm: *C_P01 Propagation for vehicular communications*	C_A06 Multi Wide Band: *C_A06 Multiband and wideband antennas*	CS45 Recent Adv Small Ant: *CS45 Recent Advances in Small Antennas*	R_A01 Rad adapt & Reconf Ant: *R_A01 Radar adaptive and reconfigurable antennas*	H_A03 Array Ant: *H_A03 Array Antennas, Antenna Systems and Architectures*	W_A04 MM Submm THz: *W_A02 Millimeter, sub-millimeter and TeraHertz antennas*					
13:30-15:00													Poster_01: *Poster_01*	Poster_02: *Poster_02*	Poster_03: *Poster_03*
15:00-16:20		Inv_01 Tue: *Inv_01 Invited Session 1*	Inv_02 Tue: *Inv_02 Invited Session 2*												
16:50-18:30		CS41 Advanced Ant Nanosat Apps: *CS41 Advanced Antenna Concepts for Nanosatellite Applications*	CS38 Machine Learning for Applied EM: *CS38 Trends and Advances in Machine Learning for Applied Electromagnetics*	F_A02 Slot-Guid-Leaky Ant: *F_A02 Slotted-, guided- and leaky- wave antennas*	CS35 Ant & Radio Channels: *CS35 Assessment and modelling of antennas and radio channels jointly*	C_A07 Ref & Transmit Array: *C_A07 Reflect arrays and transmit arrays*	L_A01 Adaptive Reconf: *L_A01 Adaptive and Reconfigurable Antennas*	CS8 Coex Wind Turb & Radar: *CS8 Recent Research on the Coexistence of Wind Turbines and Radar Systems*	H_A06 MM and THz: *H_A06 Millimeter, sub-millimeter and TeraHertz antennas*	W_A03 Array Ant: *W_A03 Array antennas, antenna systems and architectures*	B_A01 Wear Implant: *B_A01 Wearable and Implantable Antennas*	CS25 Electromagn Quant World: *CS25 Electromagnetics in a Quantum World*			
Wednesday, April 3															
08:40-			CS2 mmWave Mob		C_A07 Array Ant: *C_A02 Array antennas,*	c_A05 Arrays	L_A02 Array Ant: *L_A02 Array*	R_A02 Slot & leaky-		W_A05 WN Ant: *W_A05*					

12:30	CS40 Characteristic Modes: *CS40 Progress in the Application of Characteristic Mode Analysis*	CS47 ESA Multibeam and Reconf Ant: *CS47 ESA session: Selected papers from the 39th ESA Workshop on Multibeam and Reconfigurable Antennas*	App: *CS2 mmWave for Mobile Applications*	CS31 IET: New Antenna Systems: *CS31 IET session: New Antenna Systems involving Application of Metamaterials and Metasurfaces*	*antenna systems and architectures*	High DT: *C_A05 Arrays for High Data Transfer*	*antennas, antenna systems and architectures*	wave ant: *R_A02 Slotted and leaky-wave antennas*	CS7 IET / COST session CA15104 (IRACON): *CS7 IET / COST session CA15104 (IRACON): Propagation measurements and modelling for 5G and beyond*	*Wireless Networks Antennas*	CS30 Diagnosing & treating with microwaves: *CS30 Diagnosing and treating with microwaves - new findings covering tissue dielectric properties, medical imaging and patient studies*				
10:50-12:30			CS42 Plasma Ant: *CS42 Plasma Antennas*		CS5 Prop for UAVs: *CS5 Propagation for unmanned aerial vehicles (UAVs)*	C_A04 Cell ant: *C_A04 Cellular communication antennas*	L_P01 Radar LocSens: *L_P01 Radar, Localisation, and Sensing*	R_P20 Radar Localis: *R_P20 P20 Radar, localisation, and sensing*		MT_P11 Meas techn: *MT_P11 Measurement techniques*					
13:30-15:00														Poster_04: *Poster_04*	Poster_07: *Poster_07*	Poster_05: *Poster_05*
15:00-16:20	Inv_03 Wed: *Inv_03 Invited Session 3*	Inv_04 Wed: *Inv_04 Invited Session 4*														
16:50-18:30	CS16 EM Meth Direct & Inv Scatt: *CS16 Electromagnetic methods for direct and inverse scattering involving stratified media*	Sp_A02 Ant Arr&Systems: *Sp_A02 Antenna Arrays and Systems for Space Applications*	F_A01 Antenna Theory: *F_A01 Antenna theory, computational and numerical techniques*	CS15 AMTA: UAV-based Ant: *CS15 AMTA session: UAV-based Antenna Measurements*	C_P17 Propag Vehicul: *C_P17 Propagation for vehicular communications*	MT_P02 Propag Exp: *MT_P02 Propagation experimental methods and campaigns*	L_A04 Power Transfer I: *L_A04 Wireless Power Transmission and Harvesting I*	R_A03 Array Ant: *R_A03 Array antennas, antenna systems and architectures*	H_P01 Propag Experiment: *H_P01 Propagation Experimental Methods and Campaigns*	MT_M02 Ant Meas: *MT_M02 General antenna measurements*	B_M01 Other Meas: *B_M01 Other Measurement Topics*				

Thursday, April 4

08:40-12:30	CS34 Next-gen Comp EM: *CS34 Fundamental challenges and novel methodologies in the next-generation computational electromagnetics*	Sp_A01 Reflect Arrays: *Sp_A01 Reflect Arrays and Transmit Arrays*	CS18 AMTA: Post Processing: *CS18 AMTA session: Post Processing Techniques in Antenna Measurements*	CS39 Signal Processing for Advanced EM: *CS39 Signal Processing Techniques for Advanced Electromagnetics Synthesis, Analysis and Measurements*	CS20 ISAP: Asian Ant&Prop: *CS20 ISAP session: Recent Advances in Asian Antennas and Propagation Research*	MT_M01 RF mat char: *MT_M01 Techniques and tools for RF material characterisation*	CS11 GNSS Ant: *CS11 GNSS antennas and antenna systems*	R_A04 Radar ant: *R_A04 Radar antennas*	H_A01 MIMO Smart: *H_A01 MIMO, Diversity, Smart Antennas & Signal Processing*	F_A11 Future ant 2: *F_A11 Future antennas 2*	CS33 Horizon 2020 (EMERALD): *CS33 Horizon 2020 research and innovation session (EMERALD): ElectroMagnetic imaging for a novel genERation of medicAL Devices*				
10:50-12:30		CS49 UWB Feed and PAF Radio Telescopes: *CS49 Development of UWB Feed and PAF Technologies for Future Radio Telescopes*				MT_A08 Metamat: *MT_A08 Metamaterials, metasurfaces and EBG for antennas*		F_P06 Body Propag: *F_P06 Body-area propagation*	H_A04 Meta & EBG: *H_A04 Metamaterials, metasurfaces and EBG*	F_A07 Future ant: *F_A07 Future antennas*					
13:30-15:00														Poster_06: *Poster_06*	Poster_08: *Poster_08*	Poster_Awards: *Poster_Awards*
15:00-16:20	Inv_05 Thu: *Inv_05 Invited Session 5*	Inv_06 Thu: *Inv_06 Invited Session 6*														
16:50-18:30	CS3 Gen MoM-based Eigen Probl: *CS3 Generalized MoM-based eigenvalue problems for antennas and scattering*	CS6 AMTA: Sat&Aerosp Ant Meas: *CS6 AMTA session: Satellite and Aerospace Antenna Measurements*	F_A03 MM, Sub-mm & THz Ant: *F_A03 Millimeter, sub-millimeter and TeraHertz antennas*	F_A20 Frequency and PSS: *F_A20 Frequency and polarization selective surfaces*	C_P03 MMWave Propag: *C_P03 Millimetre-wave propagation for wireless networks*	MT_A02 Ant Theory 2: *MT_A02 Antenna Theory 2*	L_P01 Loc & Ranging: *L_P01 Localization & Ranging*	F_P05 Imaging: *F_P05 Imaging and inverse scattering*	H_A08 Metamat: *H_A08 Metamaterials, metasurfaces and EBG for antennas*	S_A26 3D Print Ant: *S_A26 3D-printed antenna technologies*	B_A02 Imag Sensing: *B_A02 Imaging, Sensing, and Radar Antennas*				

Friday, April 5

08:40-10:20		Sp_A03 Refl, Feed, Comp for Space: *Sp_A03 Reflector, Feed Systems, and Components for Space Application*	F_A04 Theory for Future Apps: *F_A04 Antenna Theory for Future Applications*	F_A32 Other topics: *F_A32 Other topics*	C_A01 Array Ant: *C_A01 Array antennas, antenna systems and architectures*	MT_P01 Propag Model: *MT_P01 Propagation modelling and simulation*	L_A05 Wear & Implant: *L_A05 Wearable and implantable antennas*	F_M01 EMI: *F_M01 EMI/EMC/PIM chambers, instrumentation and measurements*	H_P03 Propagation: *H_P03 Propagation modelling and simulation*	S_P04 Propagation: *S_P01 Propagation experimental methods and campaigns*	B_P01 Propag Bio: *B_P01 Propagation in Biological Tissues*				
10:50-12:30		Sp_A04 Reflect Arrays 2: *Sp_A04 Reflect Arrays 2*	F_A10 Meta EBG: *F_A10 Metamaterials, metasurfaces and EBG for antennas*	F_A09 Small Ant: *F_A09 Small antennas*	C_A02 MM Submm THz: *C_A02 Millimeter, sub-millimeter and TeraHertz antennas*	MT_A03 Array Ant: *MT_A03 Array antennas, antenna systems and architectures*	L_A06 Multiband & wideband: *L_A06 Multiband and wideband antennas*	F_P09 Urban UWB Propag: *F_P09 Urban and UWB propagation*	MT_P12 Propag Model: *MT_P12 Propagation modelling and simulation*	L_P15 Earth-Space: *L_P15 Earth-Space Propagation for land-mobile satellite and satellite navigation services*	B_P02 Imag Inverse: *B_P02 Imaging and Inverse Scattering*				
12:30-13:30		Closing: *Closing Ceremony*														

Monday, April 1

Monday, April 1 9:00 - 10:00

Opening: Opening Session

TOP

/ Regular Session /

Room: Oral Sessions: S1 - Krakow

Chairs: Pawel Kabacik (Wroclaw University of Science and Technology, Poland), Cyril Mangenot (Api-Space, France), Wlodzimierz Zieniutycz (Gdansk University of Technology, Poland)

Monday, April 1 10:00 - 10:40

IK_01 Mo_1: IK_01 Invited Keynote 1

TOP

Other / Regular Session / Propagation

Room: Oral Sessions: S1 - Krakow

Chairs: Romain Fleury (EPFL, Switzerland), Wlodzimierz Zieniutycz (Gdansk University of Technology, Poland)

10:00 ***Sampling Spatial-Temporal Variability of Electromagnetic Propagation in CASPER-West***

Qing Wang (Naval Postgraduate School, USA)

The Coupled Air-Sea Processes and Electromagnetic ducting Research (CASPER) is a multidisciplinary research initiative aimed at quantifying electromagnetic (EM) ducting and the associated atmospheric processes. The project involved two field campaigns on both coasts of the US. Coordinated measurements among research vessels/platforms and at the shore were made in both field campaigns resulting in a large amount of data for both the atmospheric environment and EM propagation. This paper presents a general overview of the second field campaign, CASPER-West and the ducting conditions encountered during the field campaign. Examples of the measured propagation are also given.

Monday, April 1 11:10 - 12:30

IK_02 Mo_2&3: IK_02 Invited Keynote 2&3

TOP

Other / Regular Session / Propagation

Room: Oral Sessions: S1 - Krakow

Chairs: Ala Sharaiha (Université de Rennes 1 & IETR, France), Anja K. Skrivervik (EPFL, Switzerland)

11:10 ***Achievable Throughput as the Ultimate Performance Metric of MIMO Antenna Systems: challenges in 5G and beyond***

Nicholas E Buris (NEBENS, LLC, USA & Shanghai University, P.R. China)

4G, 5G and Cognitive Radio networks employ Smart Antenna Systems. These use the additional degrees of freedom offered by their multiple antennas to exploit, among other things, multipath in the propagation environment. So, by construction, design of such systems cannot be assessed by simple performance metrics such as antenna gain, polarization and efficiency alone. At a minimum, performance has to be considered in the context of the nature and degree of the multipath as well as the types of smart algorithms that are employed during their operation in the field. Capacity, the maximum possible achievable throughput, is an appropriate performance metric when the antennas are properly combined with their propagation environment but nothing more is known about the system. When, additionally, the specific protocol characteristics of the system are taken into account, the actual throughput of the communication link becomes a more appropriate performance metric. A Cross-Layered design approach of Multiple Input Multiple Output (MIMO) antenna systems is presented in this talk. An electromagnetics exact formulation from baseband-to-baseband of a Smart Antenna System is given. The formulation consists of full wave analyses of the antenna arrays involved on both sides of the link and a plane wave decomposition for the propagation environment. Subsequently, the baseband signals are fed into link simulators, specific for each system of interest, to provide estimates of the Bit Error Rate (BER) and throughput. Illustrative examples of the methodology will be given for WiFi and cell phone designs. The new Test Plans for MIMO and Transmit Diversity Over-the-Air Performance will also be discussed in the context of this antenna system design approach. The Challenges of 5G with its proposed massive MIMO antenna systems are discussed, especially as they relate to the benefits and necessity of the Cross-Layered design approach outlined above. Cognitive Radio Spectrum Sharing approaches and Dynamic Spectrum Access algorithms are also discussed. The talk ends with recommendations on research topics to farther the state of the art.

11:50 ***From Engineering Electromagnetics to Electromagnetic Engineering: Teaching/Training Next Generations***

Levent Sevgi (Okan University, Turkey)

The role of Electromagnetic (EM) fields in our lives has been increasing. Communication, remote sensing, integrated command/ control/surveillance systems, intelligent transportation systems, medicine, environment, education, marketing, defense are only a few areas where EM fields have critical importance. We have witnessed the transformation from Engineering Electromagnetics to Electromagnetic Engineering for the last few decades after being surrounded by EM waves everywhere. Among many others, EM engineering deals with broad range of problems from antenna design to EM scattering, indoor-outdoor radiowave propagation to wireless communication, radar systems to integrated surveillance, subsurface imaging to novel materials, EM compatibility to nano-systems, electroacoustic devices to electro-optical systems, etc. The range of the devices we use in our daily life has extended from DC up to Terahertz frequencies. We have had both large-scale (kilometers-wide) and small-scale (nanometers) EM systems. Large portion of these systems are broadband and digital, and have to operate in close proximity that results in severe EM interference problems. Engineers have to take EM issues into account from the earliest possible design stages. This necessitates establishing an intelligent balance between strong mathematical background (theory), engineering experience (practice), and modeling and numerical computations (simulation). This keynote lecture aims at a broad-brush look at certain teaching / training challenges that confront wave-oriented EM engineering in the 21st century, in a complex computer and technology-driven world with rapidly shifting societal and technical priorities. The lecture also discusses modeling and simulation strategies pertaining to complex EM problems and supplies several user-friendly virtual tools, most of which have been presented in the IEEE AP Magazine and which are very effective in teaching and training in lectures such as EM Wave Theory, Antennas and Radiowave Propagation, EM Scattering and Diffraction, Guided Wave Theory, Microstrip Circuit Design, Radar Cross Section Prediction, Transmission Lines, Metamaterials, etc.

Monday, April 1 14:00 - 16:00

CS48 mm-Wave GAP Wave Techn: CS48 Integration and New Applications of mm-Wave GAP Wave Technology

TOP

High Data-rate Transfer / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Ahmed Kishk (Concordia University, Canada), Daniel Sanchez-Escuderos (Universidad Politécnica de Valencia, Spain)

14:00 ***2-Dimensional Beam Scanning Gap Waveguide Leaky Wave Antenna Array Based on Butler Matrix in Metallic 3D Printed Technology***

Hao Wang (Nanjing University of Science & Technology, P.R. China); Jianyin Cao (Nanjing University of Science and Technology, P.R. China)

In this work, a novel 2-dimensional beam scanning antenna array working at 30 GHz is proposed. The array is composed of four leaky wave antennas and a butler matrix in gap waveguide technology. The beam scanning in x-o-y plane is realized by moving one row of pins around the groove based on gap waveguide concept. The butler matrix is designed to give additional beam scanning capability in orthogonal direction. The structure is simplified, since both the butler matrix and the antenna are realized in groove gap waveguide technology. In addition, the whole antenna is designed based on metallic 3D printed technology with high integration.

14:20 ***Single-Layer Dual-Band Slot-Array Antenna in Gap Waveguide Technology***

Daniel Sanchez-Escuderos (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Rocher (Universitat Politècnica de València, Spain); José Ignacio Herranz-Herruzo and Alejandro Valero-Nogueira (Universidad Politécnica de Valencia, Spain)

This paper presents a dual-band slot-array antenna for satellite on-the-move applications. The antenna is formed by two kinds of slots working in the K band (Rx slots) and in the Ka band (Tx slots). A corporate feeding network implemented in gap waveguide technology is used to feed the slots. The use of this technology minimizes the losses in the structure and avoids mechanical assembly problems. In order to keep a low profile and a low weight in the structure, the feeding network is designed in one single layer combining adequately the use of ridge-gap and groove-gap waveguides. Dog-bone shaped slots are used in the Rx band to reduce the inter-slot spacing and minimize grating lobes problems. Results show a good return loss level within the two desired passbands, as well as the absence of grating lobes in the radiation pattern at both operating bands.

14:40 ***Design of a Holey Metasurface Prism to Reduce Dispersion in Groove Gap Waveguide Leaky Wave Antennas***

Nafsika Memeletzoglou and Eva Rajo Iglesias (University Carlos III of Madrid, Spain)

The dispersive nature of a leaky waveguide antenna causes the main beam direction to change with frequency. To reduce the main beam squinting effect in a groove gap leaky wave antenna, a holey metasurface prism is introduced. The prism is made of holes instead of pins as it was proposed in the past, to simplify manufacturing at high frequencies. The dispersion characteristics of the hole unit cell are studied and a first example of design is presented aiming to one degree or less variation of the main beam radiation angle. The example is designed at Ka band and the initial results are very promising.

15:00 ***An E-band Compact Frequency Division Duplex Radio Front-end Based on Gap Waveguide Technology***

Abbas Vosoogh (Chalmers University of Technology, Sweden); Milad Sharifi Sorkherizi (Concordia University, Canada); Vessen Vassilev and Ashraf Uz Zaman (Chalmers University of Technology, Sweden); Zhongxia Simon He (Chalmers University of Technology & Microwave Electronic Lab, Sweden); Jian Yang (Chalmers University of Technology, Sweden); Ahmed Kishk (Concordia University, Canada); Herbert Zirath (Chalmers University of Technology, Sweden)

A compact module consisting of a novel integration of an antenna, a diplexer, and millimeter-wave active circuits for low latency wireless backhaul links working at E-band is presented in this paper. The proposed radio front-end module is built by four distinct layers which are vertically stacked with no electrical contact requirement between them based on gap waveguide technology. A 16x16 corporate-fed slot array antenna is successfully integrated with a 5th order diplexer, as well as a transmitter (Tx) and a receiver (Rx) monolithic microwave integrated circuits (MMICs) in one package with a novel architecture and a compact form. The integrated radio front-end is able to simultaneously send and receive data by using a frequency division duplex (FDD) transmission scheme at 71-76 GHz and 81-86 GHz bands. A wireless data transmission is successfully demonstrated showing a data rate of 6 Gbit/s using 64 quadrature amplitude modulated (QAM) signal with a spectral efficiency of 4.4 bit/s/Hz. The proposed radio front-end provides the advantages of low loss, high efficiency, compact integration, and a simple mechanical assembly, which makes it a suitable solution for small cell backhaul links.

15:20 ***Gap Waveguide Slot Array Antenna for Automotive Applications at E-Band***

Abolfazl Haddadi (Gapwaves AB, Gothenburg, Sweden); Carlo Bencivenni and Thomas Emanuelsson (Gapwaves AB, Sweden)

High standards for safety and comfort in the modern vehicles require high precision driving assistance systems. Automotive radars play a key role because they operate also in adverse lighting and climate conditions. Automotive radars operating at mmWave frequencies (76--81~GHz) are particularly attractive because of the small sizes and wide bandwidth. Microstrip patch array antennas are the common solution, however, high dielectric losses degrade the radar's performance. To remove dielectric losses, waveguide slot arrays can be used, but at mmWaves it is hard to ensure a good electrical contact between split-blocks. Gapwaveguide technology solves this issue and the performance and robustness has been already demonstrated in different application at these frequencies. Here, we present a high gain ridge gap waveguide slot array antenna for 77~GHz automotive radar. Its narrow width (half of wavelength) allows the proposed antenna to be used in a compact array configuration to implement a bi-static radar with multiple receivers and transmitters.

15:40 ***Space Reduction Between Parallel Gap Waveguides Using Stacked Glide-Symmetric Metal Sheets***

Adrián Tamayo-Domínguez (Universidad Politecnica de Madrid, Spain); Hosnia Azkiou and Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This work presents a new configuration to create glide-symmetric structures with the objective of minimize the size of the glide-symmetric unit cell and reduce the space separation between parallel multi-layer waveguides (MLW). A rectangular waveguide transmission line is performed by stacking several thin metal sheets. To package the sheets and reduce leakage, glide-symmetric structures with different geometry are used. The proposed structure is easy to manufacture, has low transmission losses even at high frequency and reduces the space separation between parallel MLW. To show the viability of the proposed solution a straight line waveguide was designed and simulated using the unit cell proposed.

Monday, April 1 14:00 - 18:30

CS12 Reflect & Transmitarray: CS12 Reflectarray and Transmitarray Antennas for Emerging Applications TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Angelo Freni (University of Florence, Italy), Paola Pirinoli (Politecnico di Torino, Italy)

14:00 ***Advanced Synthesis of Reflectarrays Using a Spherical Mapping of the Second Order Phoenix Cell***

Raphael Gillard (IETR & INSA, France); Vincent Richard (INSA, France); Renaud Loison (IETR & INSA, France); Hervé Legay (Thalès Alenia Space, France); Maxime Romier (CNES, France); Jean-Paul Martinaud (THALES - AIRBORNE SYSTEMS, France); Daniele Bresciani and Fabien Delepaux (Thales Alenia Space, France)

A general synthesis approach is proposed for reflectarrays using second order Phoenix cells. It relies on an original spherical representation that transforms the optimization domain in a continuous and unbounded space with reduced dimension. This makes the synthesis problem simpler and automatically guarantees smooth variations in the optimized layout. The proposed mapping is combined with an ANN-based behavioral model of the cell and integrated in a min/max optimization process. As an application, a contoured beam for space communication in the [3.6-4.2] GHz band is considered. The gain improvement compared to an initial Phase Only synthesis (POS) is up to 1.62 dB. Full wave simulation of the final array is provided as a validation.

14:20 ***Design of Circularly Polarized Reflectarray Antennas Based on MoM Analysis of Multilayered Periodic Structures Involving Split Rings***

Rafael Florencio (Universidad de Sevilla, Spain); Rafael R. Boix (University of Seville, Spain); Jose A. Encinar (Universidad Politecnica de Madrid, Spain)

An efficient software has been implemented for the analysis of the scattering by multilayered periodic structures containing concentric metallic split rings in the unit cell. The software is based on the Method of Moments (MoM) in the spectral domain. Edge singularity basis functions are used in the approximation of the current density on the split rings, which makes it possible a fast convergence of MoM with respect to the number of basis functions. Since the 2-D Fourier transforms of the basis functions cannot be obtained in closed form, judicious tricks are proposed for their efficient computation. The software has been used in the design of circularly polarized reflectarray antennas under the local periodicity assumption. The results obtained in the analysis of the antennas with our in-house software have been compared with results provided by CST, and good agreement has been found. Our software has proven to be around 25 times faster than CST.

14:40 ***Ultra-wideband and Multiband Reflectarrays for Intelligent Multi-functional Platforms***

Qi Luo, Steven Gao and Wenting Li (University of Kent, United Kingdom (Great Britain)); Xuexia Yang (Shanghai University, P.R. China); Geyi Wen (Nanjing University of Information Science and Technology, P.R. China)

This paper includes two parts. In the first part, a review of techniques for designing wideband or multiband reflectarrays is presented. In the second part, two case studies including the designs of one ultra-wideband (UWB) reflectarray and one multi-band reflectarray are presented. The UWB reflectarray is a novel tightly coupled dipole reflectarray (TCDR) whose unit cell is composed of a tightly coupled dipole and a delay line. The minimum distance between adjacent cells is about 1/10 wavelength at the lowest operating frequency. The TCDR operates from 3.4 to 10.6 GHz with stable radiation patterns and aperture efficiency. The multiband reflectarray is a novel dual-band, dual circularly polarized (CP) reflectarray. The dual-band operation of the reflectarray is obtained by using the interleaved circularly polarized triangular patches as the radiating elements. Within each frequency band, two simultaneous shaped beams with different circular polarization and independent control are realized. Both reflectarrays are fabricated and measurement results are presented.

15:00 ***Low Cost High Gain Folded Reflectarray with Curved Polarizer***

Angelo Freni and Agnese Mazzinghi (University of Florence, Italy); Giorgio Carluccio (Delft University of Technology, The Netherlands)

A novel solution for folded reflectarray antennas which uses a curved (spherical) polarizer is presented. The proposed folded reflectarray shows a high gain and stable performances on a large bandwidth. Both the polarizer and the reflectarray are manufactured by using 3D printing technology. This solution allows obtaining an efficient, robust, and compact antenna with low cost manufacturing process, even for no mass production. Measurements confirm the feasibility of the proposed solution and show its performances.

15:20 ***A Dual-Band Dual-Circularly Polarized Reflectarray for K/Ka-Band Space Applications***

Parinaz Naseri and Sean V Hum (University of Toronto, Canada)

Reflectarrays (RAs) offer not only low-cost and low-profile solutions for point-to-point communications, but they also have a controllable polarization and frequency response. This property of an RA allows to realize polarization-selective and multi-band high-gain apertures. Here, we propose a novel dual-band dual-circularly polarized (CP) RA with a unique set of properties. The RA is composed of a dual-band dual-linearly polarized (LP) RA and a dual-band LP-to-CP polarizer. By dividing the CP-RA into an LP-RA and a polarizer, we obtain the ability to radiate CP shaped beams or pencil beams at desired directions for any of the dual bands and for each polarization, independently. Moreover, the polarizer has a unique property to convert an LP wave to orthogonal CP

waves at the two bands. This relaxes the feed complexity and increases the out of band rejection. The underlying unit cell of the proposed RA is designed for 18.2-18.8 GHz and 27.8-28.3 GHz. It provides a $\mathbf{323}°$ phase shift in the lower band and $\mathbf{381}°$ phase shift in the higher band while maintaining a cross polarization level more than 15 dB in both bands, and excellent decoupling between the two bands. An offset-fed RA is designed and full-wave simulation results are presented and confirm the performance of the proposed structure.

15:40 ***Electronically-Steerable Transmitarray Antennas for Ka-Band***

Antonio Clemente (CEA-LETI Minatec, France); Luca Di Palma (Space Engineering S.p.A., Italy); Fatimata Diaby (Polytech School, France); Laurent Dussopt (CEA, LETI, Minatec, France); Trung Kien Pham (University of Rennes 1 & IETR, France); Ronan Sauleau (University of Rennes 1, France)

This paper reports the design and experimental validation of electronically-steerable transmitarrays at Kaband. Two transmitarrays with 20×20 and 14×14 elements have been prototyped and full characterized, for an operation in switchable circular or linear polarization. They are based on 1-bit and 2-bit phase quantization tunable unit-cells, respectively. To control locally the transmission phase on the transmitarray aperture, two or four p-i-n diodes have been integrated on each unit-cell for the 1- or 2-bit designs, respectively. The measured broadside gain at 29 GHz of the 1- bit prototype is equal to 20.8 dBic with a 3-dB relative bandwidth of 14.6%. For the 2-bit architecture, the measured broadside gain at 29 GHz is equal to 19.8 dBi with a 3-dB bandwidth of 16.2%.

16:00 Coffee Break

16:30 ***Reflectarray Compact Antenna Test Range Concept***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); Min Zhou and Stig Sørensen (TICRA, Denmark); Ken Smart (CSIRO Astronomy and Space Science, Australia); John Kot (Young & Kot Engineering Research, Australia); John Ness (EM Solutions Pty Ltd, Australia)

This paper presents a concept for a reflectarray- based compact antenna test range. To demonstrate the concept, a 2.6m square reflectarray operating at Ka-band has been designed to emulate an offset reflector. Preliminary results indicate that a Quiet Zone >45% of the size of the reflectarray can be achieved.

16:50 ***From Inverse-Source Problems to Reflectarray Design - An Innovative Approach for Dealing with Manufacturing and Geometrical Constraints***

Marco Salucci (ELEDIA Research Center, Italy); Angelo Gelmini (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Andrea Massa (University of Trento, Italy)

An innovative approach for dealing with manufacturing and geometrical constraints in the design of reflectarrays is presented. Towards this end, the synthesis of the reflectarray surface currents is formulated as an inverse-source (IS) problem in order to exploit the non-uniqueness of the solution due to the presence of non-radiating (NR) terms. Differently from state-of-the-art methods, such a design paradigm allows to take into account specific constraints when designing the surface currents radiating the desired pattern. Some illustrative examples are shown in order to show the effectiveness and the flexibility of the proposed approach.

17:10 ***Beam Scanning Reflectarrays for DTH Application: Preliminary Results***

Paola Pirinoli (Politecnico di Torino, Italy); Thomas Lohrey (Eutelsat S.A., France); Mario Orefice, Michele Beccaria and Gianluca Dassano (Politecnico di Torino, Italy)

In this paper, some preliminary results on the feasibility analysis and prototype tests of a Direct-To-Home (DTH) receiving antenna system based on the use of a planar Reflectarrays with beam scanning capabilities, are discussed.

17:30 ***Reflectarray Antennas for 5-G Indoor Coverage***

Álvaro F. Vaquero (Universidad de Oviedo, Spain); Daniel R. Prado (Heriot Watt University & School of Engineering & Physical Sciences, United Kingdom (Great Britain)); Manuel Arrebola and Marcos R. Pino (Universidad de Oviedo, Spain)

A reflectarray antenna at 28 GHz is proposed to be used as a base station in 5-G indoor communications. The reflectarray is integrated in an office and the near-field radiated over a desktop surface is simulated. Since the near-field is not properly focused on the area defined for 5-G coverage, an optimization of the reflectarray is required. The generalized Intersection Approach algorithm is employed to optimize the radiated field at the plane of the desktop surface in order to improve the coverage area. Then, a comparison between the near-field before and after the optimization is carried out, showing a significant improvement of the coverage area. In addition, other planes are analyzed, allowing to extend the results from the optimized plane to others.

17:50 ***Sub-Array Clustering for Reconfigurable Reflectarrays with a Reduced Control Complexity***

Amedeo Capozzoli, Claudio Curcio, Giuseppe D'Elia and Angelo Liseno (Università di Napoli Federico II, Italy)

A method for the synthesis of reconfigurable reflectarray antennas with sub-array clustering is here presented. The approach is made up by two stages: an aperture synthesis devoted to the determination of the optimal clustering, common to all the beam configurations, and a reflectarray synthesis wherein the reflecting element belonging to the same cluster are driven with the same command phase.

18:10 ***Dual Reflectarray Ka-band Multibeam Antenna***

Carolina Tienda, Anestis Katsounaros and Simon J Stirland (Airbus Defence and Space, United Kingdom (Great Britain))

This paper describes a Ka-band multibeam antenna systems for a generic Continental US (CONUS) coverage. The configuration is implemented with two dual offset reflectarray antennas, one antenna works in transmit and another in receive. Each reflectarray antenna consists on a flat reflectarray as sub-reflector and a flat reflectarray as main-reflector. This antenna topology is a reduced cost alternative to a standard parabolic reflector antenna system implemented with four reflectors, also described in the text.

CS22 Reconf Ant: CS22 Reconfigurable Antennas for Compact Devices

TOP

Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Joseph Costantine (American University of Beirut, Lebanon), Leonardo Lizzi (University Côte d'Azur, CNRS, LEAT, France)

14:00 ***Superdirective and Compact Electronically-Beam-Switchable Antenna for Smart Communication Objects***

Lotfi Batel (CEA-Leti, France); Antonio Clemente (CEA-LETI Minatec, France); Christophe Delaveaud (CEA-LETI, France)

This paper proposes a directive and compact circular array composed of 9 symmetrical radiating elements (1 fed and 8 parasitic elements) with electronically beam-switching capabilities. Thanks to the superdirectivity principle and the use of a floating ground plane, the proposed closely spaced antenna array achieves a maximum realized gain of 4 dBi steered in 8 directions on the horizontal plane. The proposed antenna operates at 868 MHz with a maximum directivity of 8.5 dBi and achieving a 1-dB directivity bandwidth of 10 MHz.

14:20 ***A Method for Determination of Reconfigurable Multiantenna Systems' Performance***

Jerzy Kowalewski and Joerg Eisenbeis (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

In this paper, a methodology for determination of reconfigurable multiantenna systems' performance is proposed. The method complements the envelope correlation coefficient calculation with channel information for precise statement about antennas performance. The channel information is obtained from ray-tracer simulation. The approach is tested on three antennas and its effectiveness is proved by channel capacity simulation results. The presented method is a simple and powerful tool for evaluation of reconfigurable antennas and reconfigurable multiantenna systems and can be used during the design process.

14:40 ***A Reconfigurable Partially Reflective Surface Antenna with Enhanced Beam Steering Capability***

Lu-Yang Ji (Northwestern Polytechnical University, P.R. China); Peiyuan Qin (University of Technology, Sydney, Australia); Y. Jay Guo (University of Technology Sydney, Australia); Simone Genovesi (University of Pisa, Italy); Hailiang Zhu (The University of Hong Kong, Hong Kong); Yali Zong (School of Electronic and Information, Northwestern Polytechnical University, P.R. China)

A reconfigurable partially reflective surface (PRS) antenna with improved beam steering capability is proposed in this paper. Compared with our previous paper, the beam-steering angle can be enhanced from ±5° to ±17° with less active elements and a much smaller gain variation. It is realized by employing a compact reconfigurable metasurface as the PRS structure, which is located atop a probe-fed square patch antenna. A prototype antenna operating at 5.5 GHz is fabricated and measured. Good agreement between the simulated and measured results for the input reflection coefficients and radiation patterns is achieved, which validates the feasibility of the design principle.

15:00 ***Frequency Reconfigurable MIMO Antenna Using SRR for Multi-Band Operation***

Rifaqat Hussain (KFUPM, Saudi Arabia); Muhammad Umar Khan (National University of Sciences and Technology & Research Institute for Microwave and Millimeter-Wave Studies, Pakistan); Mohammad S. Sharawi (Polytechnique Montreal, Canada)

This work presents the design of a 4-element frequency reconfigurable multiple-input-multiple-output (MIMO) antenna. The individual element is comprised of modified annular slot antenna using split-ring resonator(SRR) loading and a rectangular slot inside the annular slot to achieve miniaturization and multi-band operation. Each slot element is loaded with a varactor diode which provides the frequency sweep in each of its operating bands. The proposed design operates in three bands covering 1.7-2.28 GHz, 2.5-2.85 GHz, and 2.9-3.1 GHz bands. The antenna is designed on a standard Rogers 4350 substrate size of 60by120by0.76 mm3. A prototype is fabricated whose measured results are in close agreement with the design simulations. The antenna is also analyzed for envelope correlation coefficient (ECC) where it shows an ECC < 0.5 in all of its operating bands, signifying good MIMO performance. The proposed design is suitable for the second generation cognitive radio applications.

15:20 ***Meandered H-Shaped Slot-line Quad-Band Frequency Reconfigurable MIMO Antenna***

Rifaqat Hussain (KFUPM, Saudi Arabia); Muhammad Umar Khan (National University of Sciences and Technology & Research Institute for Microwave and Millimeter-Wave Studies, Pakistan); Mohammad S. Sharawi (Polytechnique Montreal, Canada)

In this paper, we have proposed a miniaturized meandered slot-line based quad-band multiple-input-multiple-output (MIMO) antenna system. The proposed design consists of 2-elements meandered slot-line antenna with an H-shaped configuration. The antenna is made frequency reconfigurable using varactor diode by reactively loading the slot structure. The quad-band antenna design is reconfigurable over all the resonating bands. The meandered slot-line structure with reactive loading resulted in a size reduction of 94% as compared to conventional patch antenna and 36% compared to meandered slot antenna. The proposed antenna design operates in the frequency bands from 0.665-1.13 GHz, 1.415-2.005 GHz, 2.42-3.09 GHz, and 3.18-3.89 GHz bands, thus covering most of the modern communication standards. The proposed 2-element design is fabricated on a substrate board of dimensions 60×120×0.76 mm3 using an RO4350 substrate. The proposed design is well-suited for wireless handheld devices to be used in the second generation cognitive radio (CR) front-end applications.

15:40 ***Liquid Metal Application for Continuously Tunable Frequency Reconfigurable Antenna***

Khaled Yahya Alqurashi (Institute for Communication Systems (ICS), University of Surrey, United Kingdom (Great Britain)); Carol Crean (University of Surrey, United Kingdom (Great Britain)); James Kelly (Queen Mary University of London, United Kingdom (Great Britain)); Tim Brown (University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain))

This paper presents two different designs for frequency reconfigurable antennas capable of continuous tuning. The radiator, for both antenna designs, is a microstrip patch, formed from liquid metal, contained within a microfluidic channel structure. Both patch designs are aperture fed. The microfluidic channel structures are made from polydimethylsiloxane (PDMS). The microfluidic channel structure for the first design has a meander layout and incorporates rows of posts. The simulated antenna provides a frequency tuning range of approximately 118% (i.e. 4.36 GHz) over the frequency range from 1.51 GHz to 5.87 GHz. An experimental result for the fully filled case shows a resonance at 1.49 GHz (1.3% error compared with the simulation). Experienced rheological behavior of the liquid metal necessitates microfluidic channel modifications. For that reason, we modified the channel structure used to realise the radiating patch for the second design. Straight channels are implemented in the second microfluidic device. According to simulation the design yields a frequency tuning range of about 77% (i.e. 3.28 GHz) from 2.62 GHz to 5.90 GHz.

16:00 Coffee Break

16:30 ***Reconfigurable Wearable Antenna for Compensation of Detuning Effects***

Shengjian Jammy Chen and Damith C. Ranasinghe (The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

The presence of objects in proximity of a wearable antenna can detune its operation band. Such detuning effects through a metal object or a human tissue loading for a wearable antenna are firstly experimentally investigated in this paper. The antenna under test is a previously reported reconfigurable wearable antenna based on snap-on buttons with integrated tuning electronics. The empirical results suggest that the undesired frequency shifts will oscillate with varying distance from antenna to the loading object, but that the fractional detuning will generally remain below 8%. This provides general guidance for required compensation of the detuning effects through frequency tunability of the antenna. In addition, compensation for the observed detuning is further demonstrated using the antenna's reconfigurability. The presented findings demonstrate that reconfigurable antennas can be beneficial to wearable wireless communication systems where complex dynamic surrounding conditions are expected.

16:50 ***A New Compact Digitally Tuned Filtenna***

Ali Ramadan (Fahad Bin Sultan University, Saudi Arabia); Fatima AlZahraa Asadallah and Joseph Costantine (American University of Beirut, Lebanon); Youssef Tawk (American University of Beirut, USA)

In this paper, a new topology for a digitally tuned filtenna is proposed. The filtenna response is reconfigured by relying on a bridging digitally tunable capacitor (DTC), which is integrated into the stub of a contained coupled line band-pass filter. The contained tunable band-pass filter constitutes the feeding network of a wideband antenna structure. Activating different DTC states result in altering the electrical length of the band-pass filter's embedded stub. Such alteration tunes the operating frequency of the whole filtenna system and thus yields a narrowband frequency-tunable type of operation. The filtenna maintains acceptable gain figures and minimal distortion in its radiation characteristics across the different DTC configurations.

17:10 ***Antenna Evaluation for Increased Security in Polarization Modulation***

Cara Kataria (Electromagnetics Laboratory, USA); Jennifer T. Bernhard (University of Illinois at Urbana-Champaign & Electromagnetics Laboratory, USA)

This investigation centers on the impact of antenna design on directional polarization modulation (PM) systems for increased wireless network security. Often, new PM methods are proposed without accounting for antenna effects, which unfortunately compromises the accuracy of their evaluation. Polarization state is directly linked to the inherent physical structure of the antenna and its feed, so we propose benchmarks for comparing several aspects of the radiated polarization state from typical dual-polarized antennas. Applications wishing to relay information via polarization states should take these factors into account in order to achieve the true performance capabilities of the modulation technique.

17:30 ***A K/Ka Band Frequency Reconfigurable Transmit/Receive Antenna Array***

Marios Patriotis (The University of New Mexico, USA); Firas Ayoub (University of New Mexico & COSMIAC - University of New Mexico, USA); Christos Christodoulou (The University of New Mexico, USA)

This paper introduces a broadband right hand circularly polarized (RHCP) 16-element antenna array operating in the frequency band of 20 - 32 GHz. The array elements are truncated patches fed using a sequential rotation power divider (SRPD). The antenna can be used simultaneously in the receiving mode (Rx) and transmitting mode (Tx) by selecting the embedded reconfigurable filters. A PIN diode reconfigurable bandpass filter (BPF) is used at the Tx port in order to select the band of operation. The antenna array produces a gain of 12 - 15 dB over its operating frequencies and an axial ratio less than 0.56 dB over its operating bands. This reconfigurable antenna array can be used for K/Ka-band CubeSat communication.

17:50 ***Additively Manufactured Frequency/Radiation Pattern Reconfigurable Antenna Based on Monolithically Printed VO2 Switch***

Zhen Su (King Abdullah University of Science and Technology, Saudi Arabia); Mohammad Vaseem (King Abdullah University of Science and Technology (KAUST), Saudi Arabia); Weiwei Li (KAUST, Saudi Arabia); Shuai Yang (King Abdullah University of Science & Technology, Saudi Arabia); Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

The frequency and radiation pattern reconfigurability in antennas is usually achieved by P-I-N diodes, transistor, micro-electro-mechanical systems (MEMS), etc. based switches which are typically attached to the antennas through soldering or epoxies that leads to reliability issue. In addition, most of these switches are expensive as they are realized with complicated and costly fabrication processes. To increase the reliability and reduce the fabrication cost, additive manufacturing is a viable solution, where the switch can be simply printed at the desired place without the need of soldering, etc. In this work, we present fully printed frequency and radiation pattern reconfigurable antenna designs using a custom vanadium dioxide (VO2) ink based monolithically printed switch. In the frequency reconfigurable design, antenna operates at frequencies of 2.32-2.49 GHz and 1.93-2.03 GHz in the "OFF" and "ON" states of the switch, respectively which matches well with the simulations. In the radiation pattern reconfigurable design, an antenna array comprising two elements show a broadside maximum radiation pattern for the switch in the "ON" state and a broadside null in the "OFF" state at 5.2 GHz. The gain difference between the "ON" and "OFF" state is as high as 8 dB, which is beneficial for direction-finding applications.

18:10 ***Ultrathin Planar HIS Antenna with Beam Steering Capability for K-Band***

Ahmad Almutawa (University of California - Irvine, USA); Hamidreza Kazemi (University of California Irvine, USA); Filippo Capolino (University of California, Irvine, USA)

This paper presents a wideband, ultrathin, planar high impedance surface (HIS) antenna with a beamforming capability which operates at K-band. The HIS antenna is based on a single grounded substrate with a 2D periodic dogbone shaped metallic patches patterned on the top. The structure is designed to operate at 24 GHz with beam steering capability. The proposed structure is fed by a phase-controlled excitation network which adds the ability to steer the beam. The proposed antenna is constructed from 12 × 6 unit-cells on a very thin substrate (the overall antenna height is around a 100th of the free space wavelength). Simulation results show a maximum broadside gain of 12 dBi and, despite the ultrathin thickness, a 3dB bandwidth of 1.83 GHz with a 2 dBi gain difference in steering the beam from 0 to 45 degrees.

CS14 Periodic Structures Higher Symm: CS14 Periodic Structures with Higher Symmetries

TOP

Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Elena Pucci (Ericsson AB, Sweden), Zvonimir Sipus (University of Zagreb, Croatia)

14:00 ***Closed-Form Analysis of Artificial Dielectric Layers with Non-Periodic Characteristics***

Daniele Cavallo and Ralph van Schelven (Delft University of Technology, The Netherlands)

We present a general analysis to describe non-periodic artificial dielectric layers (ADLs). Closed-form expressions for the equivalent layer impedance are given for generic plane-wave incidence, assuming that each individual layer can differ from the others in terms of geometrical parameters. By dropping the assumption of identical layers, the given formulas are of more general applicability for flexible designs artificial dielectric slabs that are not uniform along the stratification. The analytical expressions account for the interaction between layers due to higher-order Floquet modes, thus remain valid for arbitrarily small electrical distance between layers.

14:20 ***Resonances and Embedded Eigenstates in Shifted Double Arrays of Strips***

Ana Diaz-Rubio, Xin Ma, Viktar Asadchy and Sergei Tretyakov (Aalto University, Finland)

In this presentation we show our results on studies of reflection and transmission properties of double layers of conducting strips of different symmetries, focusing of the glide-symmetric arrays. We find and discuss unique phenomena of merging full reflection and full transmission resonances and creation of bound states in the continuum in glide-symmetric arrays of negligible thickness.

14:40 ***Glide-symmetric Printed Corrugated Transmission Lines with Controlable Stopband***

Pablo Padilla (University of Granada, Spain); Angel Palomares-Caballero (University of Malaga and University of Granada, Spain); Antonio Alex-Amor (University of Malaga and Technical University of Madrid, Spain); Juan Valenzuela-Valdés (Universidad de Granada, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of

Technology, Sweden)

Here, we demonstrate that the dispersion properties of printed lines can be controlled by using glide symmetry. Glide symmetry is introduced by means of corrugations in the printed lines. The glide-symmetric configuration provides a more linear propagation constant, avoiding the presence of stopband between first and second propagating modes. Additionally, the breakage of the glide-symmetric geometry introduces a tunable stopband that can be used for filtering.

15:00 ***Low-Dispersive Glide-Symmetric Leaky-Wave Antenna at 60 GHz***

Oskar Dahlberg (KTH Royal Institute of Technology, Sweden); Elena Pucci (Ericsson AB, Sweden); Lei Wang (Hamburg University of Technology, Germany); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

Here, we demonstrate a method for producing low-loss, non-squinting, directive leaky-wave antennas (LWAs). The scanning of the radiation pattern arises from the dispersive nature of the waveguide mode, which is leaking out when opening the wave guiding structure. We cancel the dispersive behaviour by allowing the leaked waves to refract in a dispersive lens. The proposed method allows fully metallic implementation of the antenna, resulting in low losses. Furthermore, high directivity is achieved with simple feeding. The corresponding theory is outlined and used to design an antenna operating at 60 GHz. The bandwidth, with less than 1° beam scanning, is 20% in simulations and the realized gain is 17 dB across the entire bandwidth. The design is proposed as an alternative to obtain high gain antennas for 5G applications, in which low losses and narrow beams are expected to be key features for mm-waves.

15:20 ***On the Enhancement of Scanning and Gain Flatness of Leaky-Wave Gap-Waveguide Antennas with Glide Symmetry***

Lei Wang (Hamburg University of Technology, Germany); Qiang Cheng (Southeastu University, P.R. China); Wenxuan Tang (Southeast University, P.R. China); Xiaoxing Yin (State Key Laboratory of Millimeter Waves, P.R. China); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

The gain of leaky-wave antennas typically has a frequency dependence, since at different frequencies use different amount of the available aperture. The frequencies variations of the gain are more significant when the bandwidth of operation is wider. Here, we propose a leaky-wave antenna in groove gap-waveguide technology with glide-symmetric leaky pins to improve the gain flatness and scanning angle. To validate this technique, one antenna is designed following this technique. Its realized gain is improved more than 3.0 dB in the frequency band from 8.5 GHz to 14.5 GHz. The 3-dB realized gain bandwidth is enhanced from 4 GHz (36%) to 6.2 GHz (55%), with a enhanced scanning angle from 18.0 degree to 32.5 degree.

15:40 ***Mimicking Twist Symmetry Properties in Flat Structures***

Fatemeh Ghasemifard (KTH Royal Institute of Technology, Sweden); Andreu Salcedo (Polytechnic University of Catalonia, Spain); Martin Norgren and Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

Twist symmetry provides an additional degree of freedom to control the wave propagation in periodic structures. However, real twist-symmetric structures are cylindrical structures that have a high cost of manufacturing. In addition, they are not compatible with the available, low-cost and flat technologies, such as microstrip technology. Here, we investigate the possibility of mimicking the dispersion properties of twist symmetry in flat structures.

16:00 Coffee Break

16:30 ***Considerations on the Usage of Transmission Matrices to Study the Dispersion Behavior of Glide-Symmetry Structures***

Francisco Mesa (University of Seville, Spain); Raúl Rodríguez-Berral (Universidad de Sevilla, Spain); Francisco Medina (University of Sevilla, Spain)

Some effects related to the circuit modeling of periodic structures with symmetric properties are explored in this work. In particular, the consequences of introducing a type of higher-order symmetry, the so-called glide symmetry, in the unit cell of a simple periodic structure are explored in terms of the electrical distance between the individual sub-cells involved in the construction of the glide-symmetric system. The value of this distance is also shown to be very important in order to choose the appropriate method for obtaining the dispersion diagrams of the periodic structure.

16:50 ***Bloch Analysis of Glide-symmetric Structures Using a Multimode Transmission Matrix***

Mohammad Bagheriasl (Sorbonne University, France); Guido Valerio (Sorbonne Université, France)

Glide-symmetric structures have recently been used in the design of planar lenses for ultraband applications or in gap waveguide technology as electromagnetic bandgap structures. We use here a Bloch analysis to propose a method for obtaining the dispersive behavior of these structures. While previous works proposed a monomodal interaction among periodic scatterers, including higher-order modes is proved here to enhance the accuracy of the solution in dense glide-symmetric geometries.

17:10 ***Phase Shifter for Millimeter-Wave Frequency Range Based on Glide Symmetric Structures***

Angel Palomares-Caballero (University of Malaga and University of Granada); Antonio Alex-Amor (University of Malaga and Technical University of Madrid); Juan Valenzuela-Valdés (Universidad de Granada, Spain); Francisco Luna (Universidad de Málaga, Spain); Pablo Padilla (University of Granada, Spain)

The use of glide symmetry in radiofrequency devices to introduce dispersive effects has been recently proposed and demonstrated. One of these effects is to control the propagation constant of the structure. Here, we propose a mmWave phase shifter whose elements have a glide-symmetric configuration to achieve a greater phase shift in the same waveguide space than the non-glide-symmetric case. The glide-symmetric phase shifter is implemented in waveguide technology and is formed by rows of metallic pins that produce the desired phase shift. To assess the better performance of the glide-symmetric phase shifter, it is compared to its non-glide-symmetric version whose metallic pins are located only in one of the broad sides of the waveguide. The operating frequency range of the phase shifter is 67 to 75 GHz. Results show a 180 degree phase shift in regard to the reference waveguide without pins, and 50 degrees more than the non-glide-symmetric version.

17:30 ***One-Plane Glide-Symmetric Structures over Dielectric Substrate***

Adrián Tamayo-Domínguez (Universidad Politecnica de Madrid, Spain); Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This work presents a new configuration to create glide-symmetric structures in a single plane, which can be printed on the metallic face of a dielectric substrate. This type of glide symmetry facilitates fabrication and avoids alignment problems in the assembly process compared to traditional glide-symmetric structures based on several planes. The article includes a study of dispersion diagrams on the appearance of stop-bands by breaking the symmetry. Also, we present simulated S parameters in structures with 10x10 unit cells to study the attenuation in these stop-bands.

17:50 ***Analysis of Dielectric Structures with Glide Symmetry***

Zvonimir Sipus and Marko Bosiljevac (University of Zagreb, Croatia)

Artificial materials and surfaces are widely used in leaky-waves, holographic surfaces, band-gap materials, graded-index flat lenses. However, their practical implementations are usually limited in terms of bandwidth, losses, fabrication precision, input-matching. A straightforward approach overcoming these limitations has recently been proposed through specific higher symmetries in each cell of the periodic medium. Ultra-wide behaviours and large stop bands can be achieved to implement a novel generation of lenses, gap waveguides and filters. Till now, the focus has primarily been on metallic structures, while many applications require using purely dielectric structures. The presented paper is a first attempt to systematically analyze dielectric periodic structures with higher symmetry, i.e. with glide symmetry.

18:10 ***Design of Ku-band Leaky-Wave Slot Array Antenna Based on Ridge Gap Waveguide***

Mahsa Hamedani and Homayoon Oraizi (Iran University of Science and Technology, Iran); Davoud Zarifi (University of Kashan, Iran); Amrollah Amini (Iran University of Science and Technology, Iran)

In this paper the low-loss ridge-gap waveguide technology is used to feed system of travelling-wave leaky- wave slot antenna in the Ku bands. The two main section of the 1-D and 2-D planar slot array antennas are designed. The planar 1-to-4 gap-waveguide power divider is designed, where by each of its four branches feeds a linear slot array of the planar array. The computer simulations are performed by commercial software of CST Studio. The planar array has the broad side spatial scannability in the range of angles from -29 to 29 degrees. The designed slot array antenna has achieved the radiation performance of impedance bandwidth of 56%, in center frequency of 12.5 GHz.

Monday, April 1 14:00 - 16:00

CS44 Propagat in Rem Sensing: CS44 Propagation Aspects in Remote Sensing

TOP

Space / Convened Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Michael Schönhuber (Joanneum Research, Austria), Merhala Thurai (Colorado State University, USA)

14:00 ***Evaluating the Use of X-band Specific Attenuation for Rainfall Estimates Using Iowa XPol-5 Radar Scans over a Network of 25 Rain Gauges***

Merhala Thurai (Colorado State University, USA); Kumar Vijay Mishra (The University of Iowa, USA); Witold Krajewski (Iowa University, USA); Viswanathan Bringi (Colorado State University, USA)

We examine the use of specific attenuation A_h at X-band for rainfall estimates obtained from the Iowa XPOL-5 radar at locations over 25 gauges for a 9-hour event during the NASA Iowa Flood Studies (IFloodS) field experiments. We derive the specific attenuation for each gauge from the attenuation correction procedures applied for the corresponding range profiles. We compare our method with the rain rates computed using the specific differential propagation phase K_dp. Our results show that both methods yield a good agreement with the gauges but the A_h-based rainfall estimates have lower overall normalized bias than the ones obtained from K_dp.

14:20 ***Propagation Through Trees and Vegetation at Millimetre-Waves***

Robert J Watson and Jamil Bataineh (University of Bath, United Kingdom (Great Britain))

With the current focus on 5G wireless systems and the move to higher frequency millimetre-wave bands it is likely that the density of base-stations will also increase. This increase in density may well result in deployments in non-optimum locations where there may be significant penetration through trees and foliage even in urban areas as well as more rural ones. This paper reviews the current modelling approaches to scattering from vegetation and discusses the relevance and assumptions behind these. We also present some results that illustrate some of the limitations of modelling assumptions and give an indication as to how these may be solved.

14:40 ***Water Vapor Retrieval to Support Electromagnetic Wave Propagation Experiments: Results from Different Techniques***

Lorenzo Luini and Carlo Riva (Politecnico di Milano, Italy); Laurent Quibus (UCL, Belgium); Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium); Gustavo Siles (Universidad Privada Boliviana, Bolivia); Jose M Riera (Universidad Politécnica de Madrid, Spain)

The accuracy of different techniques in retrieving the integrated water vapor (IWV) is assessed. Specifically, radiosonde observation (RAOBS) data collected in two sites with different climatic conditions (Milan, Italy, and Uccle, Belgium) are used as a reference to evaluate the accuracy of IWV values extracted from the ERA5 database of the European Centre for Medium-range Weather Forecast, as well as retrieved from a microwave radiometer (MWR) and GNSS receivers. Results indicate that the MWR provides the most accurate estimate of the IWV, but also that all the considered IWV data sources can satisfactorily serve the purpose of supporting the derivation of the total tropospheric attenuation from the received beacon signal in electromagnetic wave propagation experiment.

15:00 ***Characterizing Earth Surface Scattering for an Upcoming CubeSat GNSS-Reflectometry Mission***

Franz Teschl (Graz University of Technology, Austria)

GNSS-R (Global Navigation Satellite System-Reflectometry) is a remote sensing technique that investigates GNSS signals that are reflected from the Earth in order to measure parameters of the surface. Satellite GNSS-R missions have the potential to detect sea ice, to measure sea surface height on a global scale and thus provide information on ocean circulation and retrieve wind information. In order to plan measurement missions and to interpret reflected signals the scattering behavior of the various surfaces of the Earth has to be be studied. This paper reviews propagation aspects of sea ice, sea water and soil types and discusses them in the light of an upcoming CubeSat GNSS-Reflectometry Mission.

15:20 ***Ice Cloud Detection by Millimeter Waves***

Joel Flávio (JOANNEUM RESEARCH, Austria); Félix Cuervo (Joanneum Research, Austria); Juan J. Rivera Castro and Antonio Martellucci (European Space Agency, The Netherlands); Armando Rocha (University of Aveiro & Instituto de Telecomunicações, Portugal)

The ever increasing demand for larger bandwidths is being pushing the communications satellite systems towards higher frequencies. At such frequencies the signal degradation induced by the atmosphere gets severe and therefore the usage of mitigation techniques reveals itself to be mandatory. A good understanding of the propagation channel properties is therefore required. Beyond Q-band, ice attenuation might have a role on communication satellites systems design. The present paper addresses a simple method to detect the presence of ice clouds by means of radiometric measurements relying on the difference of the ice scattering properties at 24 GHz and 90 GHz.

15:40 ***Analysis of Equatorial Rainfall Characteristics by Drop Size Distributions and Rain Rate-Radar Reflectivity Relation***

Manhal Alhilali (Universiti Teknologi Malaysia, Malaysia); Hong Yin Lam (Universiti Tun Hussein Onn Malaysia, Malaysia); Siat Ling Jong (Universiti Tun Hussein Onn Malaysia, Malaysia); Jafri Din (Universiti Teknologi Malaysia, Malaysia)

In remote sensing, it is vital to do a proper analysis of rainfall for the retrieval of rain data. The rain-induced attenuation and radar reflectivity mainly rely on drop size distribution (DSD). The rain rate-radar reflectivity (ZR) relation varies broadly over different climatic regions, rainfall regimes, and seasonal characteristics, especially in tropical regions. This study examines a one year of continuous measurements of DSD using ground-based distrometers at three different equatorial locations and investigates the rain types classification based on the microphysical properties of the rainfall. A large variation in the ZR relation parameters was discovered, highlighting the localized climate nature in the region. Additionally, the accumulated rain amounts were mainly influenced by convective rain although lower occurrence time of convective rain in comparison with stratiform rain.

Monday, April 1 14:00 - 18:30

CS36 Prop Ch Veh-to-X: CS36 Propagation Channels for Wide-Sense Vehicle-to-X Communications

TOP

Cellular Communications / Convened Session / Propagation

Room: Oral Sessions: S4-B - Lublin

Chairs: Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany), Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany)

14:00 ***A Stochastic Performance Model for Dense Vehicular Ad-Hoc Networks***

Thomas Blazek (Gusshausstraße 25 & TU Wien, Austria); Taulant Berisha (Vienna University of Technology, Austria); Edon Gashi (University of Prishtina, Kosovo); Bujar Krasniqi (University of Prishtina, Faculty of Electrical and Computer Engineering, Kosovo); Christoph F Mecklenbräuker (Vienna University of Technology, Austria)

Network level modeling of vehicular networks usually takes one of two paths. Either a mobility simulator is used to generate vehicular movement traces, combined with a network simulator to simulate packet transmissions. Or, simple stochastic assumptions, such as Poisson Point Processes and Manhattan Grids are imposed to allow analytical modeling. In this paper, we use the combination of mobility and network simulations to derive more accurate analytical models for vehicular ad-hoc networks in dense urban scenarios. Our results show that cars tend to group in clusters with approximately exponential geometric densities. Furthermore, we demonstrate that the process of interference in a dense network can be accurately modeled based on a linear function of the numbers of neighbors, as well as a Gamma distributed random process.

14:20 ***Multipath Propagation Characteristics for 5G Vehicular Communications Based on 28 GHz Expressway Measurements***

Jae-Joon Park, Juyul Lee, Kyung-Won Kim, Myung-Don Kim and Lee Kwang Chun (ETRI, Korea)

This paper presents multipath propagation characteristics, such as a power delay-Doppler profile, based on measurement data collected in expressway environments considering millimeter-wave 5G vehicle-to-infrastructure communications. With a 500 MHz-channel sounder at 28 GHz, the measurement campaigns were conducted in two expressway roads: a test expressway and an actual inter-state expressway, which are located parallel to each other in Yeoju, Korea. We investigate the propagation characteristics in terms of delay spread and Doppler frequency expressway for vehicle-to-infrastructure channels. Characteristics such as delay and Doppler frequency of the two expressway roads are compared. The results show that higher Doppler frequency is observed in the actual expressway environment, which is about 3 times higher than that of the line-of-sight component.

14:40 ***Channel Characterization for mmWave Vehicle-to-Infrastructure Communications in Urban Street Environment***

Danping He and Longhe Wang (Beijing Jiaotong University, P.R. China); Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany); Bo Ai (Beijing Jiaotong University & State Key Lab of Rail Traffic Control and Safety, P.R. China); Junhyeong Kim (ETRI & KAIST, Korea); Zhangdui Zhong (Beijing Jiaotong University, P.R. China)

Millimeter wave (mmWave) with large bandwidth is a key technology to support high-data rate vehicle-to-infrastructure (V2I) communications. In this paper, 28 GHz V2I channel is characterized for an urban street in Manhattan. By considering the recommendation in 3GPP TR 37.885, the transmitter is fixed on the street lamp with a height of 10 m, the receivers are mounted on top of the passenger car and bus with a maximum speed of 25 km/h. The ray tracing simulator with calibrated electro-magnetic parameters is employed in this work to practically conduct intensive simulations. The 3D environment model is reconstructed from OpenStreetMap. The key channel parameters, including the power delay profile, path loss, root-mean-square delay spread, K-factor, angular spreads and cross-polarization ratio, are analyzed and compared between different configurations. This work aims to helps the researchers understand the propagation channel for designing mmWave technologies and communication system in a similar scenario.

15:00 ***Measurement-based Geometrical Characterization of the Vehicle-to-Pedestrian Channel***

Ibrahim Rashdan (German Aerospace Center (DLR), Germany); Fabian de Ponte Müller (German Aerospace Center DLR, Germany); Thomas Jost and Stephan Sand (German Aerospace Center (DLR), Germany)

Reliable vehicle-to-pedestrian (V2P) communications have the ability to provide both vehicles and vulnerable road users (VRUs) with 360◦ of awareness to avoid collisions. Accurate channel models are of immense importance for developing reliable communications systems. Therefore, an accurate channel model for the V2P communications is necessary. Our work is a step towards the development of a geometry-stochastic channel model (GSCM) for V2P communications and fills an existing gap in the literature. This paper presents first wideband channel characterization results. The Kalman enhanced super resolution tracking (KEST) algorithm is employed to track multipath components (MPCs) and estimate their parameters based on the measured data. The estimated parameters are then used to localize the scatterers in the propagation environment. We then analyze the occurrence of MPCs for a line-of-sight (LoS) and an obstructed LoS (OLoS) V2P link.

15:20 ***High-speed Vehicle-to-Vehicle Radio Channel Characteristics for Suburban and Municipal Lake Region at 5.9 GHz***

Kun Yang and Ning Zhou (Super Radio AS, Norway); Terje Roste (Norwegian University of Science and Technology, Norway); Junyi Yu, Fang Li and Wei Chen (Wuhan University of Technology, P.R. China); Egil Eide and Torbjorn Ekman (Norwegian University of Science and Technology, Norway); Changzhen Li and Fuxing Chang (Wuhan University of Technology, P.R. China)

A V2V radio channel measurement campaign with a maximum distance of 6 km was performed in high way of suburban and municipal lake Region, China. In this paper, a detailed description of the channel measurement campaign including antenna setups, channel sounder configurations and other related info is given. The received signal level (RSL) is shown and compared with the Plain Earth Loss model (PEL) and the Free Space Loss model. It can be found that the PEL model predict the fading dips at short TX-RX distances (within 150 m) well. The Power-delay profiles (PDPs) are demonstrated, from which the mean excess delay and the RMS delay spread are extracted. It can be found that the 90% of the mean excess delay and the RMS delay spread are within

27 ns and 102.1 ns, respectively. The Akaike Information Criterion (AIC) is used to estimated the best-fit amplitude distribution of the small-scale fading. The Rayleigh model is found to be the best-fit model with more than 90% incident percentage in the whole route.

15:40 ***Analysis on Frequency Dependence of Large Scale Fading in Urban Environment***

Wanpeng Zhang (Beijing University of Posts and Telecommunications, P.R. China); Lei Tian (Beijing University of Posts and Telecommunications & Wireless Technology Innovation Institute, P.R. China); Tao Jiang, An Huang and Jianhua Zhang (Beijing University of Posts and Telecommunications, P.R. China); Yi Zheng (China Mobile, P.R. China)

This paper presents the frequency dependence of the path loss in urban macro-cellular (UMa) scenario under the non-line-of-sight (NLOS) case. The mobility measurements in two different cities are conducted to obtain the path loss at 2.54, 3.5, 4.9, and 5.4 GHz. Some special UMa environments are illustrated. Furthermore, their path loss characteristics and the reason for causing this phenomenon are analyzed. Comparison of the frequency dependence coefficient (FDC) in different environments are performed. The results show the values of FDC remain stable in different UMa environments under the NLOS case while other parameters of fitting results variant. Additionally, this paper investigates the FDC in different distances. It can be found that the FDC shows little dependence on the distance at low frequencies, and the FDC in different distances shows a normal distribution. The results indicate that the FDC is not influenced by environments and distances in the UMa scenario under the NLOS case.

16:00 Coffee Break

16:30 ***Comparison Analysis of 2.4 GHz and Mm-Wave V2V Channel Modelling Based on Measurements***

Hui Wang, José Rodríguez-Piñeiro and Xuefeng Yin (Tongji University, P.R. China); Haowen Wang (Shanghai Research Center for Wireless Communications, P.R. China); YU Ziming (Huawei Technologies CO., LTD, P.R. China)

In this work, a recently conducted measurement campaign for millimeter wave (mm-wave) and sub-6 GHz vehicle to vehicle (V2V) propagation channel characterization is introduced. Two vehicles carrying a transmitter (Tx) and a receiver (Rx) respectively were following with each other at an average speed of 30 km/h in the mountain area of Zhoushan, Zhejiang Province, China. The measurement was conducted with 25 MHz bandwidth at center frequency of 39 GHz and 2.4 GHz. The channel parameters investigated include the shadowing, fast fading and their auto correlations. 7 kinds of distributions of analytical expressions were used to fit the shadowing and fast fading. The results show that the shadowing and fast fading at 2.4 GHz are more severe than those at 39 GHz. After segmentation, most shadowing and fast fading segments follow gaussian distribution. Furthermore, the shadowing and fast fading at 2.4 GHz have more spacial consistency than those at 39 GHz.

16:50 ***A Novel Air-to-Ground Channel Modeling Method Based on Graph Model***

Nanxin Wang and Xuefeng Yin (Tongji University, P.R. China); Xuesong Cai (Aalborg University, Denmark); José Rodríguez-Piñeiro (Tongji University, P.R. China); Antonio Perez Yuste (Technical University of Madrid, Spain); Li Tian (ZTE Corporation, P.R. China)

Air-to-ground (A2G) communication is envisioned to support numerous applications in 5G wireless networks. In this paper, an active measurement campaign for unmanned aerial vehicle (UAV) channels is introduced. Simulation based on Graph Model (GM) is also conducted for this specific measurements. Both the measured and simulated channel impulse responses (CIRs) are extracted. Based on the CIRs, the multipath components (MPCs) are estimated by using a high-resolution algorithm derived according to the space-alternating generalized expectation-maximization (SAGE) principle. The GM simulation performance is assessed by comparing the concatenated power delay profiles (CPDPs) and MPCs with the measurement results. In addition, an object-labeled clustering method is proposed to further analyze the law altitude UAV channel contributed by individual objects/buildings.

17:10 ***Overview of Moving Network System for 5G Vehicular Communications***

Junhyeong Kim (ETRI & KAIST, Korea); Hee Sang Chung (ETRI, Korea); Gosan Noh (Electronics and Telecommunications Research Institute, Korea); Sung Woo Choi (ETRI, Korea); Ilgyu Kim (ETRI of KOREA, Korea); Youngnam Han (KAIST, Korea)

This paper presents an overview of Moving Network (MN) system for fifth-generation (5G) vehicular communications. The MN system basically supports some key functions of the 3rd Generation Partnership Project (3GPP) New Radio (NR) physical layer and it will additionally introduce several technologies dedicated for the MN system. The primary use case of the MN system is to provide a millimeter-wave (mmWave)-band broadband mobile wireless backhaul (MWB) to public transportation (e.g., city buses, express buses), enabling onboard Gigabit Wi-Fi service. In addition, the MN system will be designed to operate in the unlicensed band newly allocated by Korean government called Flexible Access Common Spectrum (FACS) to allow passengers on the public transportation to use the Gigabit Wi-Fi for free. This paper also addresses several technical challenges and a brief idea of an open-loop beam switching (BSW) technology as a viable solution to the challenges. Finally, we conduct a simple computer simulation to analyse the performance of one possible configuration of the MN system. It is observed that the MN system is severely affected by the interference from adjacent cells. Therefore, in future study, it is planned to investigate a new MN system configuration that can effectively reduce the interference received from the adjacent cells.

17:30 ***Channel Impulse Response Based Vehicle Analysis in Tunnels***

Klemen Bregar and Andrej Hrovat (Jožef Stefan Institute, Slovenia); Roman Novak and Tomaz Javornik (Jozef Stefan Institute, Slovenia)

Indoor localization and positioning is of vital importance in numerous applications. In particular, in the case of emergency events, locating and tracking of the victims, objects and rescue personnel in harsh indoor environments is still challenging. In this paper, two different approaches for the obstruction detection inside the road tunnel are analyzed. Both methods are based on the analyzing channel impulse responses (CIRs). The first parametric approach tests the use of root mean squared signal delay spread to recognize the object in an empty tunnel. Because the recognition of additional objects in already occupied tunnel is unreliable, more complex machine learning approach is also tested. The convolutional neural network (CNN) classification model for the LoS/NLoS channel detection is able to detect the object in an empty tunnel with the accuracy of more than 90%, whereas the presented multiple objects scenarios can be successfully resolved in more than 80%.

17:50 ***Network Emulator for V2X Communication Systems***

Ana Gonzalez-Plaza (Universidad Politecnica de Madrid & ETSIS Telecomunicacion & Ingeniería y Economía del Transporte, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Rafael Gutiérrez-Cantarero (Ingeniería y Economía del Transporte, INECO, Spain)

Wireless communication systems are one of the greatest revolutions of our time. In this context, there are still many challenges to be addressed in the field of intelligent transport systems. These are related to the solution of the great difficulties that these complex environments of propagation present such the mobility aspect. In this sense, the objective of this paper is to present a network emulator for V2X communication systems. The advantages of this device is that in in a simple, controlled and reproducible way, user can find the zones of possible lack of wireless coverage and unsuccessful handover process. As a result, the problematic in high-speed environments can be more easily assessed. The developed system allows emulating the communication links between three vehicles and one base station, controlling the amplitude in a range of 95dB, the phase in 360º and the Doppler shift from 0 to 1 kHz. For this purpose, a propagation model and a time series generator that is synchronized with the speed of the mobile are used.

CS29 Small Antenna Design: CS29 Small Antenna Designing Methods and Measurement

TOP

Localization & Connected Objects / Convened Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Katarzyna Jagodzińska (Koszalin University of Technology, Poland), Ala Sharaiha (Université de Rennes 1 & IETR, France)

14:00 ***Small New Wearable Antennas for IOT, Medical and Sport Applications***

Albert Sabban (ORT BRAUDE COLLEGE, Israel)

Efficient small antennas are crucial in the development of wearable wireless communications and medical systems. Low efficiency is the major disadvantage of small antennas. Meta material and fractal technology are used to improve the efficiency bandwidth of small antennas. Moreover, the dynamic range and the efficiency of communication system may be improved by using active wearable antennas. Amplifiers may be connected to the wearable antenna feed line to increase the system dynamic range. Novel wideband passive and active efficient wearable antennas for IOT, BAN and 5G applications are presented in this paper. The gain and directivity of the patch antenna with Split-ring resonators, SRR, is higher by 2.5dB than the patch antenna without SRR. The resonant frequency of the antennas with SRR is lower by 5% to 10% than the antennas without SRR. Active small wearable antennas may be used in receiving or transmitting communication, IOT and medical systems. For example, the active slot antenna gain is 12+2dB for frequencies from 1.25GHz to 3.25GHz. The active slot antenna Noise Figure is 0.6+0.2dB for frequencies ranging from 1GHz to 3.3GHz.

14:20 ***Beyond Antenna Q: On Reactive Energy and the Need for a Spatio-Temporal Dynamical Paradigm***

Said Mikki (University of New Haven, USA)

We question the common emphasis on antenna quality factor Q and input impedance within fundamental research in antenna theory and applied electromagnetics. Alternatively, the requirements and need for a fully-fledged spatio-temporal dynamical approach to the description and analysis of energy transformations, especially in the antenna near one, is highlighted, particularly in light of the authors' recent computational FDTD-IDM method. An outline of the derivation of general time-dependent reactive energy is given, providing foundations for the FDTD-IDM approach. Some of the physical, conceptional, and engineering aspects of the results are also discussed.

14:40 ***Size Reduction of Optical Leaky Wave High Gain Antenna by Photonic Reflector***

Hiroyuki Arai, Hashiguchi Hiroshi and Toshihiko Baba (Yokohama National University, Japan)

Optical leaky wave antennas (OLWA) are physically small, but electrically large size due to very short wavelength, and are expected to use for optical wireless communication (OWC) such as beyond 5G and light detection and ranging (LIDAR) in sensing. Very high propagation loss requires high directivity gain for short range communication and the feeding structure is very large to excite uniform field distribution in the waveguide cross section. This paper presents the dramatically size reduction of its feed by replacing the conventional adiabatic taper waveguide with offset reflector consisting of artificial photonic crystal. Gain enhancement is also achieved by employing waffle (WWG) or waffle-iron (WIWG) waveguide, which allow to enhance 3 dB gain as compared to conventional grating waveguide (GWG).

15:00 ***Compact and Wearable Microstrip-based Textile Antenna with Full Ground Plane Designed for WBAN-UWB 802.15.6 Application***

Purna B. Samal (College of Science and Technology, Bhutan); Ping Jack Soh (Universiti Malaysia Perlis (UniMAP) & Katholieke Universiteit Leuven, Malaysia); Zahriladha Zakaria (Universiti Teknikal Malaysia Melaka, Malaysia)

The design and evaluation of a microstrip-based textile antenna for the IEEE 802.15.6 Wireless Body Area Network Ultrawideband (WBAN-UWB) application is presented in this paper. This textile antenna is designed with an innovative and compact UWB radiator on top of the overall structure with a full ground plane on its reverse side. The radiator based on a microstrip patch combined with multiple miniaturization methods resulted in a simple topology and a compact size of 39 mm x 42 mm x 3.34 mm to facilitate fabrication using simple tools. Meanwhile, the full ground plane enables the antenna operation in the vicinity of the human body with minimal body coupling and radiation towards it, ensuring operational safety. Besides the mandatory WBAN-UWB low and high band channels, the designed antenna also operated in five other high band channels, exhibiting a total bandwidth of 3.4 GHz.

15:20 ***Application of a C-tuner to Aperture Tuning of a Handset Antenna Inspired by Characteristic Modes***

Henning Hartmann (Leibniz University Hannover, Germany); Anthony Thomas and Valentyn Solomko (Infineon Technologies, Germany); Dirk Manteuffel (University of Hannover, Germany)

In this paper, an approach to develop a tunable antenna for small terminals or smartphones is presented. Instead of tuning a self resonant antenna structure, a generic setup with a capacitive coupling element as common in current mobiles is used. To tune this antenna, the promising approach of aperture tuning is implemented. To realize this, a 5 bit C-tuner is used as tunable element at the antennas aperture. The positioning of the tuning element is shown based on a development process combining characteristic modes, full-wave field simulations and circuit simulations with Advanced Design System (ADS). Combined with a switched impedance tuning circuit, it is possible to tune this generic antenna element for low- and midband operation.

15:40 ***Beneficial Interaction of Coupling and Mismatch in a Two-Antenna System***

Jari-Matti Hannula, Anu Lehtovuori, Rasmus Luomaniemi and Tapio Saarinen (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

Multiantenna systems are commonplace in the wireless world. Multiple antennas in a limited volume have coupling among them, which can in many cases be detrimental. However, there are also use cases where the coupling can be a benefit. In this paper, we derive an analytical result to show a benefit of interaction in a two antenna case through weighted feeding, which has been used in the recently proposed antenna cluster concept. The theoretical results are demonstrated with three examples, where different types of two-feed antennas are designed to a mobile phone chassis.

16:00 Coffee Break

16:30 ***Patch Antenna System for CubeSats in L Band***

Miroslav J. Veljovic and Anja K. Skrivervik (EPFL, Switzerland)

An L-band patch-antenna system for CubeSat applications is presented in this paper. The high-permittivity dielectric loading reduces the size of individual antennas to make them suitable for a CubeSat platform. Two circularly polarized patch antennas were designed for the downlink and uplink frequencies of 1.53 and 1.63 GHz, respectively, and the antenna prototypes were characterized. A two-element, sequentially rotated antenna array was designed using the uplink patch element at 1.63 GHz, with a beam tilt of 20° from broadside. The array is to be employed in a system of four arrays that provide two tilted beams with dual-band coverage in each beam, for an increased system capacity. The arrays are located on the backside of the 3U-CubeSat solar panels, facing Earth. While the panels are stowed, the antennas of two arrays are interleaved, reducing the required stowage volume.

16:50 ***Electrically Small Antenna Design: From Mobile Phones to Implanted Sensors***

Anja K. Skrivervik (EPFL, Switzerland); Marko Bosiljevac and Zvonimir Sipus (University of Zagreb, Croatia)

In this review, intended to introduce the convened session on electrically small antennas, we describe the evolution of electrically small antennas from the early nineties, when the boom of mobile phones triggered an intense research activity on the, to our days, where virtually everything has a wireless connection. A special emphasis will be set on antennas for wearables and implants, as in those cases the strategies and limitations derived for electrically small antennas radiating into free space do not hold anymore. We will present the design strategies based on fundamental limitations and the special care that should be taken to measure and simulate such antennas.

17:10 ***Miniaturization Strategy of Compact Antenna Using Magneto-Dielectric Material***

Lotfi Batel (CEA-Leti, France); Christophe Delaveaud and Jean-François Pintos (CEA-LETI, France)

This article describes a strategy of miniaturization for an electrically small Monopolar Wire-Plate Antenna (MWPA) loaded by Magneto-Dielectric Material (MDM). The multiplication of antenna's shorted wires lead to a stronger interaction with the material. An electrically small six wires MWPA loaded with MDM is designed at VHF band (sphere radius around λ0/15). While conserving interesting performances (total efficiency=70%), the designed antenna is 27% smaller than a single shorted MWPA without loading material.

17:30 ***Superdirective Closely-Spaced Arrays***

Pavel Hazdra (Czech Technical University in Prague, Czech Republic); Tomas Lonsky (Czech Technical University, Czech Republic); Jan Kracek (Czech Technical University in Prague, Czech Republic)

In this paper we employ the concept of source currents to express the directivity of an array in generalized matrix form. It allows to find the excitation currents that maximize directivity for given array. First we demonstrate this method on array of two isotropic radiators and express the resulting superdirective currents in closed form. Then, using the proposed approach, a superdirective closely-spaced array of two loaded dipoles is designed using full-wave simulator CST Microwave Studio.

17:50 ***On Q-factor Bounds for Lossy Embedded Antennas in Electrically Small Devices***

Lars Jonsson (KTH Royal Institute of Technology, Sweden); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France)

In this paper we investigate a method to determine the best available bandwidth for small embedded antennas. The available bandwidth depend both on the size and the position within a device, but also on the ohmic losses in the structure. Here we show a non-convex optimization problem, utilizing stored energies, and phrased as a current optimization problem we can determine the available bandwidth in a given region for a range of surface resistances. We illustrate the method by comparing the results with embedded antennas in a small IoT terminal. We show that an optimized embedded come rather close to the bounds.

18:10 ***Compact UHF RFID Antenna for On-body Applications***

Alexandru Tatomirescu (Universitatea Politehnica Bucuresti)

In this paper, a compact antenna design is presented which can be used for a passive RFID UHF tag in close proximity of the human body. The design is tuned for the European RFID standard 868 MHz band. The results show that the antenna performance is not degraded significantly even when it is placed 2 mm away from the human body. The antenna has a small size compared with the wavelength at the operating frequency, occupying the area of a credit card (80 mm x 50 mm) and having only a 4 mm thickness. Compared with the examples in literature and despite its small size, the design is one of the most efficient even in free space. It uses inexpensive FR4 printing manufacturing technology. The simulated read range of the RFID tag when equipped with a commercial RFID tag chip is of 9 m when it placed on the human body and the reader and tag are aligned.

Monday, April 1 14:00 - 16:00

CS10 Snowpack monitoring: CS10 Microwave techniques, modelling, systems, and antennas for snowpack monitoring and snow-related applications

TOP

Radars / Convened Session / Antennas

Room: Oral Sessions: S4-D - Bytom

Chairs: Achim Heilig (Munich University, Germany), Marco Pasian (University of Pavia, Italy)

14:00 ***Impulse Radar Systems to Continuously Monitor Accumulation and Melt Within the Percolation Zone of the Greenland Ice Sheet: Spatial Representativeness of Point Data***

Achim Heilig (Munich University, Germany); Anika Albrecht (Potsdam University, Germany); Michael MacFerrin (University of Colorado, USA); Olaf Eisen (AWI Bremerhaven, Germany)

Observations of changes within firn and snow of the Greenland Ice Sheet (GrIS) are typically either point measurements or cover areas of several square kilometers (remote sensing data). Very few studies attempt to quantify the spatial variability of snowpack parameters to assess the representativeness of point measurements over larger areas. Here, we relate snowpack conditions observed in a snow pit to area-wide variabilities in snow depth along a 24 km radar transect. We used geostatistical analysis tools to extrapolate measured two-way travel time from radar antennas along the transect over an area of roughly 16 km2. We show that a single point measurement within the percolation zone of the GrIS can be regarded as representative for a larger area with an uncertainty of below 5%. However, this statement is only correct if the influence of small scale variabilities can be minimized by a larger measurement extent.

14:20 ***Monitoring Snow Water Equivalent Using Low-Cost GPS Antennas Buried Underneath a Snowpack***

Ladina Steiner and Michael Meindl (ETH Zurich, Switzerland); Charles Fierz and Christoph Marty (SLF, Switzerland); Alain Geiger (IGP, ETH Zurich, Swaziland)

The GPS refractometry method is presented to derive snow water equivalent (SWE) by using refracted GPS L1 signals from a low-cost antenna buried underneath the snowpack. The GPS monitoring system is installed at 2500ma.s.l. in the Swiss Alps. GPS refractometry is able to correct the influence of the snowpack above the buried antenna. The systematic and stochastic snow induced effects in the GPS residuals are significantly reduced by estimating the SWE above the antenna. The refined method is able to estimate the SWE hourly over a full season and results are highly correlated to the reference sensors data with a median relative bias of less than 10 %.

14:40 ***In-situ Snowpack Inspection Using Bi-static Radar***

Jon Håvard H Eriksrød, Kristian G Kjelgård and Tor Sverre Lande (University of Oslo, Norway)

This paper presents a upward looking bi-static, synthetic aperture radar (SAR) instrument optimized for long-term, non-invasive, remote snowpack monitoring in polar areas. Single-chip radar SoC facilitate a power-efficient implementation potentially operating on battery/solar power. To show the feasibility of detecting and accurately measuring the density and thickness of snow layers a controlled experiment using phantom materials was conducted. The permittivity, which is proportional to the equivalent snow density and layer thickness was accurately estimated indicating excellent performance using SAR.

15:00 ***The Relationship Between the Multi-Temporal Sentinel-1 Backscattering and the Snow Melting Dynamics in Alpine Regions***

Carlo Marin, Giacomo Bertoldi, Valentina Premier, Mattia Callegari and Christian Brida (Eurac Research, Italy); Kerstin Hürkamp and Tschiersch Jochen (Helmholtz Zentrum München, Germany); Marc Zebisch (Eurac Research, Italy); Claudia Notarnicola (EURAC, Italy)

Snow melting is a complex process generally characterized by a moistening, ripening and run-off phase. Identifying the timing of these phases is crucial for river discharge, avalanches and snow contaminants monitoring. An alternative to the sporadic and punctual snow water equivalent (SWE) and liquid water content (LWC) measurements is represented by Synthetic Aperture Radar (SAR). We analyze the correlation between the multi-temporal C-band SAR backscattering and the snow melting timing. The backscattering was compared with in situ observations and snow modelling simulations for two test sites in the Alpine region. SAR sensitivity to LWC variation and snow properties enables the identification of the snow melting phases. A strong decrease of the backscattering in correspondence of an increase of LWC, e.g. during the moistening phase, is observed. Furthermore, an increase of backscattering happens in correspondence of SWE decrease, e.g. during the run-off phase. We discuss the possible mechanisms which affect SAR backscattering, related both to LWC and snow structure variations. The presented investigation could have relevant application for monitoring and predicting the snowmelt progress over large regions.

15:20 ***Three-antennas FMCW Radar for Self-Consistent Snowpack Monitoring***

Marco Pasian and Pedro Fidel Espin Lopez (University of Pavia, Italy); Massimiliano Barbolini (University of Pavia & Flow-Ing S. R. L. La Spezia, Italy); Fabio Dell'Acqua (University of Pavia, Italy)

Microwave radars have the potential to monitor the internal structure of the snowpack, delivering real-time and non-destructive measurements. Recently, an innovative radar architecture able to identify some of the most important snowpack parameters without external aids has been demonstrated. A key point of this new architecture is the use of two independent receiving antennas, and one transmitting antenna. This paper presents the comparison between two different implementations, based either on one physical antennas miming two receiving antennas, or based directly on two physical receiving antennas. Experimental results are reported to discuss the different advantages and disadvantages.

15:40 ***Recent Development on Search of Avalanches Victims with Monopulse Antenna Mounted on a Small UAV***

Serge Bories (CEA, France); Kaoutar Allabouche (CEA LETI, France); Norbert Daniele (CEA/LETI, France)

A complete system is designed to localize the avalanche victims through their smartphone radio transmission. The innovation takes advantage from the speed and medium altitude of a small UAV equipped with a monopulse antenna technique to find the direction of arrival of radio signals. A system model is developed to optimize search strategy duration and specify both the antenna array features (gain, beamwidth) and the UAV trajectory strategy. The different components such as the 2x2 patch array with circular polarization and the monopulse RF circuit are described and co-designed. The performance of 2D angular estimations are analyzed.

CS24 Arrays for 5G: CS24 Antenna Arrays for 5G and Beyond

TOP

High Data-rate Transfer / Convened Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Y. Jay Guo (University of Technology Sydney, Australia), Richard Ziolkowski (University of Technology Sydney, Australia & University of Arizona, USA)

14:00 ***A Highly-Integrated MIMO Antenna Unit***

Steven Gao (University of Kent, United Kingdom (Great Britain)); Hang Xu (The University of kent, United Kingdom (Great Britain)); Hai Zhou (Huawei Technology (UK), United Kingdom (Great Britain)); Hanyang Wang (Huawei Technologies, United Kingdom (Great Britain)); Yu Jian Cheng (UESTC, P.R. China)

A novel highly-integrated multiple inputs multiple outputs (MIMO) antenna unit, termed as "Integrated Even/Odd-Mode Antenna" (IEOMA), is proposed in this paper. Despite the small size of the IEOMA antenna, it has two important advantages compared to other smart phone antennas: 1) It is capable of achieving wide-coverage radiation patterns in three dimensions. This is achieved by enabling the antenna to operate at two different modes including the even and odd modes simultaneously, and complementary radiation patterns can be achieved at each mode; 2). This IEOMA antenna can achieve high isolation between two antennas in different modes even if they are overlapped with each other, hence it is suitable for realizing compact-size MIMO antenna systems by using this antenna as the unit element.

14:20 ***Thinned Massive Antenna Array for 5G Millimeter-Wave Communications***

Yanhui Liu (University of Technology Sydney); Qianke Luo and Ming Li (Xiamen University, P.R. China); Y. Jay Guo (University of Technology Sydney, Australia)

massive antenna array is one of the key technologies for 5G millimeter-wave communications. In this paper, a modified iterative FFT is introduced to obtain thinned massive arrays. An example is given for synthesizing a 128-element thinned array with U-slot microstrip antenna working at 27.5-28.5 GHz. Simulated results show that the thinned array has improved beam resolution and sidelobe performance than those for a conventional 128-element array.

14:40 ***Butler Matrix Based Multi-Beam Base Station Antenna Array***

He Zhu (University of Technology Sydney, Australia); Haihan Sun (University of Technology, Sydney, Australia); Can Ding (University of Technology Sydney (UTS), Australia); Y. Jay Guo (University of Technology Sydney, Australia)

In this paper, a three-beam Butler matrix as well as its antenna arrays is presented for cellular base stations. The three-beam Butler matrix is able to generate three beams in the azimuth plane, which can increase the capacity of base stations. Striplines are used for developing the 3 × 3 Butler matrix, which is compose of directional couplers and phase shifters. To extend the 3 × 3 Butler matrix to a 3 × 5 one, unequal power dividers are also require. To verify the beam-forming network, 5-element dual-polarized antenna arrays covering LTE band are developed. Multiple beams are obtained by feeding the antenna array with the augmented 3 × 5 Butler matrix. The design is verified by both simulation and experiments.

15:00 ***Design of s/ka Dual-Band Shared-Aperture Massive MIMO Antenna Array for 5G Communication***

Han Zhou and Ronghong Jin (Shanghai Jiao Tong University, P.R. China); Junping Geng and Xianling Liang (Shanghai Jiaotong University, P.R. China); Weiren Zhu and Chong He (Shanghai Jiao Tong University, P.R. China)

In this context, a shared-aperture design of S/Ka dual band Massive MIMO antenna array is proposed for 5G communication. The antenna array contains a 2×2 S-band MIMO array and an 8×8 Massive MIMO array. The operating frequency covers the 5G commercial frequency range. The S-band antenna utilizes a layer of metasurface to achieve an extremely low profile, which is transmissive for S-band antenna and also acts as a extended ground plane for Ka-band antenna array. A stack-up structure is adopted for shared aperture design with Ka-band array located at the centric top of S-band array. The simulation results suggest that the shared-aperture antenna array with quite low profile has good polarization isolation, antenna element isolation as well as S-Ka dual-band antenna isolation.

15:20 ***MIMO Antenna Array for 5G Smartphone Applications***

Ying Liu and Yang Lu (Xidian University, P.R. China); Yu Zhang (Xidian University, Xi'an, P.R. China); Shuxi Gong (Xidian University, P.R. China)

A compact eight-port multiple input multiple output (MIMO) antenna system operating at 3.5 GHz band (3400-3600 MHz) for future 5G mobile phones is proposed in this paper. The proposed array is composed of eight gap-coupled IFA antennas with a compact size of 7×5.2mm2, which are mounted on the two long frames of the smartphone. To reduce mutual coupling, inverted T-shape slots etched on the ground are introduced between two adjacent antennas. The simulated results show that the impedance bandwidth (S11<-10dB) of the proposed antenna array can cover 3400-3600 MHz, and the isolation of any two ports is better than 16dB. The calculated envelop correlation coefficients (ECCs) are less than 0.02, showing a promising diversity performance for 5G smartphone MIMO systems.

15:40 ***Realization of Low-Complexity Reconfigurable Huygens'' Metasurfaces***

Min Yin Xu and Sean V Hum (University of Toronto, Canada)

An impinging wave incident on a Huygens' metasurface can be arbitrarily manipulated by inducing the electric and magnetic currents required by the equivalence principle along the surface. Reconfigurable Huygens' metasurfaces have the potential of obtaining wideband tunable responses by incorporating tunable elements into the surface, making them suitable for applications requiring real-time reconfigurability. In this paper, we present the design of a unit cell in a low-complexity reconfigurable Huygens' metasurface that requires fewer diodes and is simple to manufacture, compared to current implementations. Simulation results show that the designed unit cell has low insertion loss and linear phase profile over a wide bandwidth.

CS19 COST CA15104 (IRACON): BAN CS19 COST session CA15104 (IRACON): Measurements and Simulations in Channel Modelling in Wireless Body Area Network

TOP

Wireless Networks and Defense and Security / Convened Session / Propagation

Room: Oral Sessions: G2- Opole

Chairs: Luis M. Correia (IST/INESC-ID - University of Lisbon & INESC, Portugal), Krzysztof K. Cwalina (Gdansk University of Technology, Poland), Patrick Van Torre (Ghent University, Belgium)

14:00 ***Long-range Body-To-Body LoRa Link at 868 MHz***

Patrick Van Torre (Ghent University, Belgium); Thomas Ameloot (Ghent University - imec, Belgium); Hendrik Rogier (Ghent University, Belgium)

For the Internet of Things, LoRa is an important standard for low-power wide area sensor networks. LoRa communication employs chirp spread spectrum modulation in sub- GHz frequency bands, combining the benefits of both in order to enable low-power kilometer-range wireless data communication. LoRa modulation provides a high link budget and additionally, sub-GHz bands possess excellent radio propagation characteristics. A LoRa transceiver was integrated onto a textile substrate integrated- waveguide antenna in order to perform long-range body-to-body communication. The unit is a fully autonomous wearable wireless sensor node, including a transceiver, processor, sensors, flash memory and a flat battery, all integrated at the back of a textile antenna. The design and characteristics of the unit are described, including radiation patterns of the fully assembled unit. Finally, an outdoor long-range performance test is performed as a proof of concept.

14:20 ***Modeling of Shadowing States of On-Off Body Propagation of Wireless Body Area Network During Human Walking Using Simple Geometrical Calculation***

Takahiro Aoyagi (Tokyo Institute of Technology, Japan)

Propagation channel of body area networks fluctuates by shadowing caused by human movement. In this paper, on-off body propagation of body area network during human walking for seven on-body antennas and an external access point is geometrically modeled by plane wave incident direction parameters; zenith and azimuth. By shadowing state estimation using ray tracing technique, LOS/NLOS state is calculated for each zenith and azimuth parameters. The LOS/NLOS boundary of shadowing state for individual time frame and receiving position is approximated by two boundary lines with four parameters. As a result, time variation of the on-off body shadowing parameters of human walking between the receiving position on right hand and the external access point is shown. To investigate other human movements and exhibit derived parameters are left for further report.

14:40 ***Wideband Off-Body Channel Characteristics with Dynamic User***

Kenan Turbic (IST - University of Lisbon & INESC-ID, Portugal); Slawomir J. Ambroziak (Gdansk University of Technology, Poland); Luis M. Correia (IST/INESC-ID - University of Lisbon & INESC, Portugal); Marko Beko (ULHT/UNINOVA & UNINOVA, Caparica, Portugal)

This paper presents the preliminary results of a dynamic off-body channel characterisation study, based on wideband measurements at 5.8 GHz in an indoor environment. The Channel Impulse Response (CIR) was measured for a scenario with the user approaching and departing from the off-body antenna. A CIR deconvolution procedure was performed jointly in two polarisations, and the received signal power, Cross-Polarisation Discrimination (XPD), delay mean and standard deviation were calculated based on the estimated path delays and amplitudes. The statistical analysis is performed, and the obtained results show large variations of the CIR parameters. The XPD is observed to vary up to 21.3 dB.

15:00 ***Impact of the Variability of the EM Properties of Biological Tissues on UWB Channel Modelling for Implanted Devices***

Alejandro Fornes-Leal (Institute of Telecommunications and Multimedia Applications, Spain); Concepcion Garcia-Pardo (Universitat Politècnica de València & Institute of Telecommunications and Multimedia Applications (iTEAM), Spain); Sofia Perez-Simbor (Univeristat Politècnica de València, Spain); Narcis Cardona (The Polytechnic University of Valencia, Spain)

Wireless Body Area Networks are being massively developed nowadays. Wireless capsule endoscope, implanted sensors and wearable devices are a few examples of applications of this kind. Antennas for these networks are designed taking into account the electromagnetic properties of the surrounding biological tissues. However, many authors just consider the typical values rather than the whole range of possible electromagnetic properties. The same occurs when modeling the radio channel between transmitting and receiving side, where the body tissues are the propagation medium itself. In this paper, we aim at presenting how this variability can affect the propagation characteristics of the channel as well as the performance of in-body and on-body antennas in UWB frequencies. To this end, electromagnetic software simulations are carried out using a human CAD model with skin, fat and muscle tissues in the 3.1 - 5.1 GHz band. In addition, the fitting coefficients of a 2-pole Debye equation of the average, maximum and minimum permittivities of these tissues are provided, using the data gathered in a previous measurement campaign. Results showed that the dielectric variability has a great impact on the system losses, especially in the upper simulated frequencies, and that it may affect as well the reflection coefficient of WBAN antennas. However, it is worth mentioning that this variability will not have the same impact regardless the antenna tested, so in their design process researchers should check that they are versatile enough to work with some detuning of the surrounding electromagnetic properties.

15:20 ***Distributed Antenna Systems Used for Indoor UE to Access Point Communications at 60 GHz***

Seong Ki Yoo and Lei Zhang (Queen's University Belfast, United Kingdom (Great Britain)); Simon Cotton (Queen's University, Belfast, United Kingdom (Great Britain)); Hien Ngo (Queen's University Belfast, United Kingdom (Great Britain))

This paper empirically investigates the performance of distributed antenna systems (DAS) based on switched diversity combining for indoor user equipment (UE) to access point (AP) communications at 60 GHz. Among the candidate pool of switched diversity combining techniques, the pure selection combining (PSC), switch-and-examine combining (SEC) and SEC with post-examining selection (SECps) schemes are utilized to combine the received composite fading signals. Unlike the PSC scheme, the performance and complexity of the SEC and SECps schemes vary according to the switching threshold that is used, highlighting the importance of the selection of an appropriate switching threshold level. Also in this study, diversity specific equations are developed under the assumption of independent and identically distributed F composite fading channels. These are then utilized to model the composite fading behavior observed at the output of each of the combiners. Over all of the measurement scenarios considered in this study, it is found that the theoretical models provided an adequate fit to the composite fading observed at the output of each of the combiners.

15:40 ***Applicability Limits of Simplified Human Blockage Models at 5G mm-Wave Frequencies***

J. Samuel Romero-Peña (Universitat Politècnica de València, Spain); Narcis Cardona (The Polytechnic University of Valencia, Spain)

This paper analyzes the feasibility of using a simple diffraction model to compute the blocking of the human body to millimeter wave radio frequencies in indoor environments. The model makes a set of approximations that are evaluated to determine the applicability limits of such simplified approach, in particular for the human body blockage case. The work presented here: (1) describes briefly the mathematical support that is used to model the concealment using the Knife-Edge model, (2) identifies the potential simplifications applicable to the mathematical model implementation that allow a 3D geometric human body to be modelled with simple 2D shapes, (3) characterizes the polarization influence on the mm-wave blocking for such simplified human body models.

Monday, April 1 14:00 - 18:30

CS27 COST session CA17115 (MyWAVE): CS27 COST session CA17115 (MyWAVE): Advancements in Electromagnetic Hyperthermic Technologies and Dielectric and Thermal properties of tissues

TOP

Biomedical / Convened Session / Propagation

Room: Oral Sessions: A2- Ustka

Chairs: Emily Porter (National University of Ireland Galway & Translational Medical Device Lab, Ireland), Charles Sammut (University of Malta, Malta)

14:00 ***Challenges and Opportunities in Thermal Tissue Modelling for Electromagnetic Applications***

Margarethus M. Paulides (Eindhoven University of Technology, The Netherlands); Kemal Sumser (Erasmus MC Cancer Institute, The Netherlands); Iva Ribeiro (Erasmuc MC, The Netherlands); Esra Neufeld (IT'IS Foundation, ETH Zurich, Switzerland); Gerard C. van Rhoon (Erasmus MC Cancer Institute, The Netherlands)

Electromagnetic (EM) waves are being used in a wide range of applications in health monitoring, disease diagnosis and therapy. Such approaches increasingly rely on joined electromagnetic and thermal modelling for their development and optimization. A key hurdle in these simulations are gaps in, or absence of, the knowledge on thermal tissue properties. In this paper, we review the current status quo in thermal modelling with respect to the models and tissue properties used, including thermoregulation tissue properties. In addition, we review methods to obtain quantitative and reliable thermal and thermoregulation tissue properties, and suggest technology improvements that could solve the thermal tissue property gap aimed at advancing electromagnetic medical technologies.

14:20 ***Broadband Dielectric Properties of Porcine Lung as a Function of Temperature***

Jan Sebek (Kansas State University & Czech Technical University, USA); Punit Prakash (Kansas State University, USA)

Computer modeling of microwave ablation technique plays important role in many aspects of treatment delivery such as applicator design, ablation zone prediction or treatment planning. In order to increase the precision of models or to be able to assess the uncertainty of model predicted therapy outcome, the values of tissue dielectric parameters, their spread and dependency on temperature are required. While some data were reported on liver tissue properties in the past, there is limited amount of information with regards to the lung tissue. We report on our recent measurements of lung dielectric properties and their thermal dependency. Moreover, the dielectric properties of bovine muscle were measured as a control and validation of our measurement technique. Both relative permittivity and effective conductivity tend to decrease with rising temperature and their decay can be modelled by a linear function within temperature range from 27 °C to 94 °C.

14:40 ***Tissue Permittivity Measurement with Concurrent CT Imaging: Analysis of Heterogeneity Effects***

Sevde Etoz and Christopher Brace (University of Wisconsin-Madison, USA)

Tissue dielectric properties are important parameters in microwave sensing and microwave ablation as the tissue contrast and input to simulations, respectively. Coaxial probes are widely used in property measurements, however inhomogeneities in tissues might result in inconsistent measurements. To further analyze this issue, computed tomography (CT) was used to image assumed coaxial probe sensing volume in an ex-vivo lung tissue. Even though density of lung and measured permittivity had positive correlation, high variation in data suggested limitations in CT image resolution might have contributed the variation. Further analysis with simulations showed an inclusion with the width of 0.3 mm and 50% of the permittivity of the background tissue can impact measurements significantly.

15:00 ***Permittivity and Conductivity Estimation of Biological Scenarios via 3D Microwave Tomography***

Martina Teresa Bevacqua (Università Mediterranea di Reggio Calabria, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Tommaso Isernia (University of Reggio Calabria, Italy); Lorenzo Crocco

(CNR - National Research Council of Italy, Italy)

The estimation of the effective electrical properties of biological tissues is relevant to different medical applications, ranging from hyperthermia treatment planning to dosimetry. In this contribution, we introduce a novel inverse scattering approach to cope with this problem. This latter is relevant to microwave tomography and is herein formulated in 3D geometry. More in details, the procedure performs the inversion of measured fields scattered by the investigated biological scenario by taking advantage from the spatial priors derived from segmented medical images and conveniently representing the unknown electrical properties.

15:20 ***Muscle and Adipose Mimicking Solutions for Applications in Microwave Medical Imaging***

Daphne Anne Pollacco, Malcolm Caligari Conti, Lourdes Farrugia and Charles Sammut (University of Malta, Malta)

The present study deals with synthesizing mixture solutions which can be used as muscle and adipose tissue mimics for applications in microwave medical imaging. Dielectric parameters were measured as a function of frequency between 500 MHz and 50 GHz and mixtures utilizing concentrations of bovine serum albumin (BSA) in phosphate buffered saline (PBS) were synthesized with the aim of mimicking in vivo and ex vivo muscle tissues. Emulsions consisting of concentrations of peanut oil and Triton X 100 (TX) in PBS solutions were also synthesized to mimic in vivo and ex vivo adipose tissue. Results were compared to measured dielectric parameters of in vivo and ex vivo biological tissues from a previous study. Good agreement with experimental results was observed implying that our hypothesis was fulfilled. Such solutions might ultimately be utilised in the construction of human body phantoms for narrowband and ultra-wideband microwave devices for near field breast cancer imaging.

15:40 ***Tissue Mimicking Materials for Breast Phantoms Using Waste Oil Hardeners***

Simona Di Meo (University of Pavia, Italy); Ioannis Iliopoulos (University of Rennes 1); Marco Pasian (University of Pavia, Italy); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Lorenzo Pasotti (Università degli Studi di Pavia, Italy); Maxim Zhadobov (University of Rennes, France); Giulia Matrone (University of Pavia, Italy)

Realistic breast phantoms are often required for supporting the development of microwave and mm-wave imaging systems for breast cancer detection. A number of phantoms have been proposed in the literature, but they are often realized using non-common or toxic materials, and characterized only for the microwave regime. Recently, mmwaves have been also proposed for screening purposes, especially for breast with a high fat content, to provide the resolution vital to detect early-stage cancer masses. Consequently, we proposed several recipes that can be used to create tissue-mimicking materials able to reflect the dielectric properties of different human breast tissues, from fat to neoplastic tissues. In this paper, we present new recipes specifically conceived to mimic up to 50 GHz the dielectric properties of very fat tissues, difficult to achieve otherwise. The involved materials are deionized water, sunflower oil, waste-oil hardener, and two different surfactants (lecithin and Polysorbate 80), all very cheap, easy-to-manage, not-toxic and common materials.

16:00 Coffee Break

16:30 ***A Coaxial Microwave Heating Applicator with Double Loading Discs for a Confined Power Loss Density Pattern***

Suramate Chalermwisutkul (King Mongkut's University of Technology North Bangkok & The Sirindhorn International Thai-German Graduate School of Engineering, Thailand); Vasan Jantarachote (King Mongkut's University of Technology North Bangkok, Thailand); Kirote Arpanutud and Prayoot Akkaraekthalin (King Mongkut's University of Technology North Bangkok, Thailand); Dirk Heberling (RWTH Aachen University, Germany)

A microwave heating applicator with a confined heating pattern is presented in this paper. Compared to conventional coaxial applicators, the proposed design is immune to influences of surrounding boundaries. This feature is provided by double capacitive loading discs at the beginning and the end of the applicator's tip. Hot spots with high power loss density are formed by such loading elements where strong electric fields are presented. In addition, the proposed applicator can also be used as a sensor with a high sensitivity by measuring the return loss over the frequency at the feed port while the applicator is immersed into the liquid under test.

16:50 ***Microwave Thermal Ablation: Focusing Energy in Target Tissue Using Fat Layer***

Anna Bottiglieri (Translational Medical Device Lab & National University of Ireland, Galway, Ireland); Laura Farina (National University of Ireland Galway & CURAM, Ireland); Atif Shahzad (National University of Ireland, Galway, Ireland); Declan O'Loughlin (National University of Ireland Galway, Ireland); Martin O'Halloran and Muhammad Adnan Elahi (National University of Ireland, Galway, Ireland)

Microwave thermal ablation therapy is a minimally invasive technique introduced in the interventional oncology practice to treat a range of cancerous pathologies. Whereas satisfying results are obtained with the treatment of large and relatively homogeneous areas (e.g. hepatic tumours), treatments of small and inhomogeneous targets are currently under investigation. Minimizing the transversal dimension of applicators represents a crucial aspect in the case of sensitive structures (e.g. blood vessels) surrounding target area. Despite several improvements being proposed, a minimal invasive applicator suitable for small targets adjacent to crucial structures remains an unsolved issue, so far. A proposal to achieve a compromise between a minimally-invasive applicator geometry and a focused thermal pattern is presented in this work. The idea concerns exploiting insulator properties of fat layer, which normally coats the organs in the abdominal cavity. In this scenario, fat tissue is used to focus the heating pattern in the target tissue. Low effective conductivity of fat tissue induces a low absorbed power of the tissue and a consequent low heating of the area. Based on these evaluations, fat layer is also used to avoid unnecessary and potentially dangerous overheating of surrounding healthy structures.

17:10 ***"Temperature-Inspired" Optimization in Hyperthermia Treatment Planning***

Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Margarethus M. Paulides (Eindhoven University of Technology, The Netherlands); Tomas Drizdal (Czech Technical University in Prague, Czech Republic); Gerard C. van Rhoon (Erasmus MC Cancer Institute, The Netherlands); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

In the last decades, considerable efforts were taken in the development and the clinical implementation of hyperther- mia treatment planning. Still, no general consensus exists whether the specific absorption rate or temperature should be optimized. An interesting possibility would be a novel strategy exploiting the advantages of both approaches. In this contribution, we pro- pose and test an innovative, still straightforward, "temperature- inspired" hyperthermia treatment planning routine.

17:30 ***FOCO: A Novel Versatile Tool in Hyperthermia Treatment Planning***

Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Giada Battaglia and Martina Teresa Bevacqua (Università Mediterranea di Reggio Calabria, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

The possibility of ultimately control the power deposition represents the way towards a wide spread adoption of hyperthermia in the clinic. The end goal is represented by the possibility of uniformly shaping the temperature over the target area while keeping it arbitrarily bounded elsewhere. In this respect, an innovative SAR-based optimization strategy, the so called Focusing via Constrained power Optimization (FOCO), has been proposed and recently tested in the clinic. Thanks to its huge versatility (as well as several advantages), different derivations of FOCO were developed addressing different clinical needs. In this communication we aim at review some of these derivations under a common framework.

17:50 ***Examination of Zinc Ferrites vs. Iron Oxides as Contrast Agents for Microwave Systems***

Rachita Lahri and Mohammed Rahman (King's College London, United Kingdom (Great Britain)); Javier Hernández-Gil and Nicholas Long (Imperial, United Kingdom (Great Britain)); Panagiotis Kosmas and Maria Thanou (King's College London, United Kingdom (Great Britain))

Iron oxide nanoparticles are biocompatible nanoparticles (NPs) which may have the potential to increase the dielectric contrast of targeted tissues, hence assist in microwave imaging as a contrast agent. This study investigates the physico-chemical stability and dielectric properties of iron oxide NPs. Synthesized zinc ferrites were characterised in addition to three commercial iron oxide suspensions. Zinc ferrites were synthesised using a thermal decomposition method and functionalised with a maleated polymer. The nanoparticle's characteristics were analysed for size and metal composition. Zinc ferrites showed higher dielectric contrast compared with the commercial iron oxides.

18:10 ***A Novel Approach of Brain Tumor Detection Using Miniaturized High-Fidelity UWB Slot Antenna Array***

Mohammad Ojaroudi (University of Limoges/CNRS, France); Stéphane Bila (XLIM UMR 7252 Université de Limoges/CNRS, France); Mahdi Salimi (Gazi University, Ankara, Turkey)

In this paper, a compact multi-static microwave imaging system using a novel design of high-fidelity ultra-wideband (UWB) slot antenna is employed to improve the accuracy of tumor detection inside full head phantom. In order to create a conformal microwave imaging system 18 elements of the proposed UWB slot antennas are simulated in CST medium around the phantom inside a designed matching medium. The proposed slot antenna consists a pair of C-shaped slots on the defected ground structure (DGS) which provides a wide usable fractional bandwidth of more than 100% (3.19-10.73 GHz) and fidelity factor more than 80%. In addition, a novel hierarchical calibration method is employed to improve the accuracy reconstructed image results. This calibration includes all delays of multi-static antenna array to put more energy at coherence reflected signal integration. Simulated results are presented to validate the effectiveness of the proposed method for precisely localizing small targets.

Monday, April 1 16:30 - 18:30

CS21 IET/AMTA: 5G and Beyond CS21 IET/AMTA Session: Trends and Measurement Challenges for 5G and Beyond

TOP

Cellular Communications / Convened Session / Measurements

Room: Oral Sessions: S1 - Krakow

Chairs: Tian Hong Loh (UK, National Physical Laboratory, United Kingdom (Great Britain)), Janet O'Neil (ETS-Lindgren, USA)

16:30 ***Measurements and Evaluation of Active Phase Arrays in 5G UE Device***

Kun Zhao (Sony Mobile Communication AB, Sweden & Aalborg University, Denmark); Olof Zander and Thomas Bolin (Sony Mobile Communications, Sweden); Zhinong Ying (SONY Mobile Communications AB, Sweden); Shuai Zhang and Gert Pedersen (Aalborg University, Denmark)

In this paper, the evaluation of antenna systems in the 5th generation (5G) User Equipment (UE) in millimeter wave (mmWave) frequency range is introduced. Different to conventional mobile antennas operate below 6 GHz, the spherical coverage is a new but critical aspect of mobile handsets, and the cumulative distribution function (CDF) of effective isotropic radiated power (EIRP) has been adopted by the 3rd Generation Partnership Project (3GPP) to evaluate the spherical coverage of mmWave UE. Typical antenna systems in 5G mmWave UE, including phased arrays and beam switched arrays are presented. Their performance is analyzed based on measurement results, and major factors restrict the spherical coverage of mobile handsets typed UE will also be discussed. More active antenna measurement results will be given in the presentation.

16:50 ***Link Performance Evaluation of 5G Mm-Wave and LiFi Systems for the Transmission of Holographic 3D Display Data***

Tian Hong Loh (UK, National Physical Laboratory, United Kingdom (Great Britain)); David Cheadle (National Physical Laboratory, United Kingdom (Great Britain)); Xiping Wu and Harald Haas (The University of Edinburgh, United Kingdom (Great Britain)); Juan Liu (Beijing Institute of Technology, United Kingdom (Great Britain)); Pan He (Beijing Institute of Technology, P.R. China); Yong Bi (Casiris Technology Co., Ltd., P.R. China)

This paper presents an evaluation of link performance of a 5G millimetre wave (mm-wave) and a LiFi (light fidelity) system for the transmission of holographic 3D display data via over-the-air (OTA) links. In order to reduce the transmission payload the data is compressed from 256-level gray scales to 8-level gray scales which results in the required transmission data throughout to be about 1.5 Gbps. The compressed data are then encoded and decoded through holographic encoding and decoding systems between transmitting and receiving ends. The 5G mm-wave system is designed to operate at 26.5 GHz with carrier aggregation to increase the throughput rate of the system using multiple vector transceiver modules. The LiFi system is designed to operate with the optical spectrum of four colors: red, green, blue, and yellow. Wavelength division multiplexing (WDM) is applied to efficiently modulate the four wavelengths to improve the link data rate. Results between show that, without forward error coding (FEC), the 5G mm-wave system is able to achieve a real-time data transmission rate of 0.6 Gbps with 16-QAM (quadrature amplitude modulation) with the symbol error rate of 0.22% over a 0.13 m wireless link whereas, with FEC, the LiFi system is able to achieve a data transmission rate of 15.7 Gbps with the bit error rate below 3.8x10^-3 over a 1.6 m wireless link.

17:10 ***Proof of Concept Experiment for Single Probe MIMO OTA Measurement System***

Qiwei Zhang (University of Chinese Academy of Sciences, P.R. China); Tian Hong Loh (UK, National Physical Laboratory, United Kingdom (Great Britain)); Wuxiong Zhang (Shanghai Research Center for Wireless Communications, P.R. China); Yang Yang (ShanghaiTech University, P.R. China); Fei Qin (Chinese Academy of Sciences, P.R. China)

The novel applications of 5G bring advantages with measurement difficulties. Especially the multi-probe based MIMO OTA measurement will confront difficulties and challenges in the adaptation to 3D spatial channel models. To face this challenge, we propose single-probe based MIMO OTA measurement architecture to satisfy 3D channel emulation while reduce the cost of both instrument and infrastructure. In the proposed system, the fading paths have been reallocated in time slices instead the spatial angles, which will be emitted out with a single probe moving along the corresponding AoA (angle of arrival) sequences. A time synthesizer will temporally store these time slices, which will be aligned and synthesized to generate the expected fading signals. As the most important challenge in this method is the time alignment, a two-layer time alignment algorithm has been utilized in this work. The first layer roughly aligns the time slices with system triggers. The second layer attaches a Chirp based preamble to the faded signal slice, which will be utilized to generate high accurate synchronization peak for time alignment. The experimental results show the feasibility of the two-layer time alignment algorithm, which will enable the implementation of single-probe based MIMO OTA measurement system in our future work.

17:30 ***Using Reverberation Chambers to Test 5G-enabled Devices***

Robert Rehammar (Bluetest AB & Chalmers University of Technology, Sweden); John Kvarnstrand (Bluetest AB, Sweden)

In this paper we review the current status of over-the-air testing of 5G enables devices with emphasis on reverberation chamber technology. For 5G devices, beamform- ing is a central concept and the paper includes a discussion on beamforming aspects of 5G. We show, using simulations, how phase steered antenna arrays can be tested and faults detected in rich isotropic multipath-environments. A novel scheme for measuring directivity related quantities such as EIRP is introduced and limitations and advantages are listed. Results from transmitting a 5G NewRadio signal, carried at 28 GHz, measuring throughput is also demonstrated and some challenges are discussed.

17:50 ***Investigation of Enhanced Backscatter Coefficient in a Reverberation Chamber in Frequency, Spatial and Power Domains***

Tianyuan Jia and Yi Huang (University of Liverpool, United Kingdom (Great Britain)); Qian Xu (Nanjing University of Aeronautics and Astronautics, P.R. China)

The enhanced backscattering phenomenon inside an electromagnetic reverberation chamber (RC) is investigated in frequency, spatial and power domains. Experimental results demonstrate that the enhanced backscatter coefficient (e_b) tends to be higher in value and more spatially dependent as frequency increases which is different from what are expected. In addition, the measured e_b could be sensitive to the signal output power, which again, becomes more pronounced with increasing frequency. It is found that when the output power is below a certain threshold dependent on the number of modes excited (M), or frequency and chamber size, the measured e_b begins to decrease and becomes inaccurate. Therefore, care should be taken when utilizing e_b for antenna and communications measurements, such as the fifth generation (5G) over-the-air (OTA) test where the frequency goes to millimeter waves (mm-wave) and the propagation attenuation becomes very large.

18:10 ***New and Continuing Measurement Challenges for 5G mmWave and Beamforming Technologies***

Michael D. Foegelle (ETS-Lindgren, USA)

As the wireless industry rushes forward with the development and deployment of 5G radio technology, there are still fundamental questions, both in radio design and manufacturing, especially in the millimeter wave (mmWave) FR2 band. With this headlong rush, 3GPP has made some tentative steps forward in over-the-air test and measurement of the various radio metrics, but many of the original issues remain and new ones have come to light. This paper will attempt to cover the progress to date and a number of the outstanding issues still to be resolved.

CS17 Ground Terminal Sat Comm: CS17 Ground terminal needs and technologies for broadband satellite communications

TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S4-A - Poznan

Chairs: Nelson Fonseca (European Space Agency, The Netherlands), Jaroslaw (Jarek) Kmieciak (SES Networks, The Netherlands)

16:30 ***A Ka-band GaAs Multi-function Chip with Wide-band 6-Bit Phase Shifters and Attenuators for Satellite Applications***

Jin-Cheol Jeong (Electronics and Telecommunications Research Institute, Korea)

This paper presents a monolithic microwave integrated circuit multi-function chip with wide operating frequency range of 20 GHz to 32 GHz for a Ka-band phased array antenna in satellite and 5-G applications. This chip, implemented using a 0.5-μm GaAs pHEMT process includes several functional blocks of 6-bit digital phase shifters, 6-bit digital attenuators, amplifiers, and a serial-to-parallel converter for the digital circuit control. The coverage ranges of the phase shifter and attenuator are 360 degree with a step of 5.625 degree and 23.625 dB with a step of 0.375 dB, respectively. This chip demonstrates the RMS phase and attenuation errors of 5 degree and 0.3 dB, respectively, in the frequency range. The chip has a compact size of 3 mm × 3 mm, and exhibits a typical gain of 2 dB.

16:50 ***Affordable Large Scale Active-Phased Array Antenna for Ka-Band Mobile SATCOM Applications***

Wael Abdel-Wahab, Hussam Al-Saedi, Mohsen Raeis-Zadeh, Ehsan Haj Mirza Alian, Ahmad Ehsandar, Guoyan Chen, Ardeshir Palizban, Naime Ghafarian, Heba El-Sawaf, Mohammad-Reza Nezhad-Ahmadi and Safieddin Safavi Naeini (University of Waterloo, Canada)

This paper presents the design aspects and the implementation Of an electronically scanned active-phased array antenna (A-PAA) for high throughput Ka-band mobile satellite communication (SATCOM) applications. First, an A-PAA which consists of 64 (4×16) elements is presented as a first step in the evolution towards the final modular design concept. Next, a low cost/complexity solution based on a modular architecture is proposed. With this approach, A-PAAs of any size, shape, and configuration can be made of the same intelligent building block (active sub-array module). The measured results of the modular array show that the antenna's main beam can be steered to ± 70° off the boresight.

17:10 ***A Low-cost, Flat, Electronically Steerable Array Antenna for New Massive NGEO Constellations Ground Terminals and Future 5G***

Christian Weickhmann, Arshad Mehmood, A. Burak Olcen and Yue Sun (ALCAN Systems GmbH, Germany); Rolf Jakoby (Institute for Microwave Engineering and Photonics, Technische Universität Darmstadt, Germany)

Recent developments around non-geostationary constellations created a strong demand for electronically steerable satellite antennas. In parallel, 5G networks are rolled out and Ka band applications gain momentum. Both markets require mass-manufacturable low-cost antennas. ALCAN's Liquid Crystal based antenna technology offers a solution to both satellite and terrestrial fields and promises to open a new segment of low-cost antennas.

17:30 ***A Dual-Mode CTS Architecture for Dual-Polarized and Circularly-Polarized Antenna Systems***

Maciej Smierzchalski (CEA, France); Francesco Foglia Manzillo (CEA-LETI, France); Michele Del Mastro (University of Rennes 1, France); Nicolas Capet (ANYWAVES FRANCE, France); Baptiste Palacin (CNES, France); Ronan Sauleau (University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

Beam-scanning capability, polarization reconfiguration, flat and low profile are key assets for ground terminal antennas in satellite communication systems. This paper presents a novel parallel-fed continuous transverse stub antenna architecture enabling dual-linear and circular polarization operation using a single radiating aperture. The antenna consists of an array of long slots and a corporate feed network comprising bimodal parallel-plate corrugated waveguides, which are designed to support two orthogonally-polarized modes. A Ka-band prototype has been fabricated using stereolitography to demonstrates the dual-polarization operation. Two quasi-optical systems are employed to separately excite the antenna with each mode and form seven beams. The system achieves a good performance for both modes between 28.5 GHz and 30.5 GHz over an angular range in elevation of +/-22°.

17:50 ***Design Options for a Multi-beam/multi-band AIRBORNE Antenna***

Ashok Rao and Aditya Chatterjee (SES); Jeffrey Payne (SES, USA); Javier Trujillo (SES, Luxembourg); Michael Blefko (SES Government Solutions, USA); Jarek Kmieciak (SES, The Netherlands)

A multi-band/multi-beam airborne antenna provides the flexibility to use different satellites in different bands to enhance coverage, increase throughputs and enable access to different services on different satellites. The key requirements for such an antenna were presented in [1]. This contribution provides a review of the antenna specifications and proposes some design options for

such antennas.

CS46 GPR: CS46 Theoretical, Algorithmic, and Experimental Advances in GPR

Radars / Convened Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Custodio Peixeiro (IST-University of Lisbon, Portugal), Marco Salucci (ELEDIA Research Center, Italy)

16:30 ***Advanced Buried Object Detection by Multichannel,UAV/Drone Carried Synthetic Aperture Radar***

Eric Schreiber, Andreas Heinzel, Markus Peichl and Marius Engel (German Aerospace Center (DLR), Germany); Werner Wiesbeck (Karlsruhe Institute of Technology, Germany)

The great innovations of Synthetic Aperture Radar (SAR) technology during the past years stimulated new applications in several areas. While in the past SAR was primarily operated for airborne and spaceborne applications, novel operations for quite low altitude like surveillance of cities, local agricultural applications, or even buried object detection, are of new interest. For such operations the wellknown and established SAR system concepts should apply similarly, while the technology has to be transferred to the state of the art and new platforms like UAVs or drones. The paper addresses the special concept for a SAR to detect buried mines. It combines a novel DLR approach based on multistatic observation with the capability to create nearly arbitrary azimuth sampling trajectories. By providing very high resolution it is possible to even identify man-made objects like landmines in the SAR image by their spatial radar-cross section (RCS) distribution. These capabilities allow advanced detection capabilities and satisfy the ultimate demand for buried object identification, both being great improvement in landmine detection and related activities. Beside this concept the paper addresses an idea on robust high-precision positioning, which is indispensable for a successful SAR system. It is based on a photogrammetric method providing the trajectory, the orientation of the UAV and the three dimensional (3D) ground surface as a side effect as well. Measurement results are shown confirming the feasibility of the proposed approach.

16:50 ***Impact of Root Diameter and Water Content on Tree Roots Detection Using Ground Penetrating Radar***

Abderrahmane Aboudourib (CentraleSupélec, France); Mohammed Serhir (GeePs, CentraleSupelec, France); Dominique Lesselier (L2S UMR 8506 (CNRS - Supélec - Université paris Sud 11), France)

Several factors limit the root detection using Ground Penetrating Radar (GPR). By using simulations under optimal conditions in terms of mode operation, we established a two-dimensional grid enabling to evaluate the detectability of roots according to their diameter and water content. The decision about root detectability is made by applying a chain of post-processing to simulation outputs. Using a bi-static GPR system involving folded complementary bowtie antennas, we also carried out laboratory experiments on "freshly-extracted" roots inside an anechoic chamber in order to get experimental radargrams and have a reference for simulation color scale.

17:10 ***A Method to Detect Subsurface Targets by Under-sampled Multifrequency Data***

Adriana Brancaccio (Seconda Università di Napoli, Italy); Giovanni Leone (Università della Campania Luigi Vanvitelli, Italy); Raffaele Solimene (Università degli studi della Campania Luigi Vanvitelli, Italy)

Imaging buried objects embedded within electrically large investigation domains can require a large amount of measurement points. Thus, the need to reduce the number of spatial measurement points arises. Here, a method for detecting and localising shallowly buried scattering targets from under- sampled multifrequency far-zone data is proposed and checked by numerical examples

17:30 ***Recent Advances in High-Resolution Ground Penetrating Radar on Board an Unmanned Aerial Vehicle***

María García Fernández (University of Oviedo, Spain); Yuri Álvarez (Universidad de Oviedo, Spain); Borja Gonzalez-Valdes and Yolanda Rodriguez-Vaqueiro (University of Vigo, Spain); Ana Arboleya (University Rey Juan Carlos, Spain); Fernando Las-Heras (Universidad de Oviedo, Spain)

In this contribution, a methodology to process the measurements gathered with a novel subsurface imaging system is presented. This system is based on mounting a Ground Penetrating Radar (GPR) on board an Unmanned Aerial Vehicle (UAV). Among other advantages, the system does not need to be in contact with the soil, which is particularly useful for detecting dangerous objects (e.g., landmines). However, there are still several challenges that should be faced, such as speeding up the measurements processing so as to bring it closer to real-time operation. In this sense, two different focusing methods are applied to several in-flight measurements to generate a high-resolution synthetic aperture radar image by coherently combining all the measurements. This coherent combination is possible due to the use of a high accuracy positioning system. Both focusing methods are compared in terms of image quality and computational time for detecting metallic and dielectric targets.

17:50 ***Forward-Looking GPR Imaging with Near-Optimal 3-D Synthetic Array***

Jianping Wang (Delft University of Technology, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

In this paper, we propose an Elevation-Radial scanned Synthetic Aperture Radar (E-RadSAR) for forward-looking ground penetrating radar (GPR) imaging. The E-RadSAR exploits the advantages of both RadSAR and Elevation-Circular SAR (E-CSAR) by utilizing the SAR technique in the cross- and down-range directions for signal acquisition. It could be implemented with fewer antennas compared to the RadSAR but provides higher spatial resolutions than that of E-CSAR. These features make it very attractive for space- and/or cost-constrained imaging applications, for instance, the GPR systems used for tunnel boring machines (TBM). However, the E-RadSAR synthesizes a three-dimensional (3-D) array by taking measurements in a volume, which makes the traditional sampling criterion no longer applicable for its sampling strategy design. To tackle 3-D (synthetic) array sampling/design, we formulate it as a sensor selection problem and suggest an efficient selection algorithm, i.e., modified clustered FrameSense (modified CFS). Then it is used for 3-D array sampling design. The imaging performances of the resultant near-optimal 3-D arrays are demonstrated through numerical simulations.

18:10 ***HF Antenna Prototype for Geophysical Ground Penetrating Radar***

Lai Bun Lok (Lancaster University, United Kingdom (Great Britain)); Keith Nicholls and Hugh Corr (British Antarctic Survey, United Kingdom (Great Britain))

We describe an HF antenna design and implementation intended for ground penetrating radar applications in glaciology and hydrology. The HF antenna is based on modifications of a twin terminated folded dipole design. Prototypes of the HF antenna were built and then tested with a frequency-modulated continuous-wave radar operating from 25 MHz to 45 MHz, in a preliminary experiment for subsurface water detection.

CS32 Transformation Optics: CS32 Transformation Optics for Antenna Design

Future Applications / Convened Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Vincenzo Galdi (University of Sannio, Italy), Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

16:30 ***Plasmon-exciton Coupling of an Arbitrarily Orientated Quantum Antenna in a Metallic Nanocavity***

Rui-Qi Li, Wenxuan Tang and Tie Jun Cui (Southeast University, P.R. China)

In previous works, we have comprehensively studied the plasmon-exciton coupling in a dimer cavity with both symmetric and asymmetry geometries based on the transformation optics (TO) theory. In this paper, we utilize TO again to study the plasmon-exciton coupling of an arbitrarily orientated quantum emitter (antenna) (QE) in a metallic nanocavity, mainly focus on the relationship between coupling effect and the orientation of the transition dipole moment of the QE.

16:50 ***Omnidirectional Radiation Lens Design of Vortex Beam Carrying Orbital Angular Momentum Based on Spatial Transformation***

Jianjia Yi (Xidian University, P.R. China); Zhe Shi (State Key Lab of ISN, Xidian University, P.R. China); Xueqi Cao, Rui Feng and Hailin Zhang (Xidian University, P.R. China); Shah Nawaz Burokur (LEME, France)

Vortex beams carrying orbital angular momentum suffers from their divergence characteristics. To convert the directional beam to an all-directional one, a transformation electromagnetics based lens is proposed for a potential all-dielectric realization. Employed above a micro-strip patch antenna circular array, the emitted beam is steered to the direction parallel to the ground plane. The functionality of the proposed lens is numerically validated. Simulations results of both near-field distribution and far-field patterns demonstrate the omnidirectional radiation in the horizontal plane.

17:10 ***Realization of Transformation Optics Designs Using Broadband Anisotropic Glide-symmetric Structures***

Mahsa Ebrahimpouri and Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This paper presents a method to realize anisotropic 2D (two dimensional) designs of transformation optics with a wide band of operation. Glide-symmetric structures have been proven to provide wider bandwidth and higher equivalent refractive index than the conventional structures. Here, an anisotropic glide-symmetric unit cell is designed and studied. The simulated results prove that this structure also follows the general behavior of the structures possessing glide symmetry, in providing wider bandwidth and higher equivalent refractive-index. Using the designed anisotropic glide-symmetric unit cell, a 30% compressed Luneburg lens is designed and simulated that operates in a wide band (1-6 GHz).

17:30 ***Transformation Optics and Related Techniques for GRIN Lens Design***

Sawyer D Campbell (The Pennsylvania State University, USA); Douglas H Werner and Pingjuan Werner (Pennsylvania State University, USA)

Gradient-index (GRIN) optics has seen a renewed interest due in large part to the development of Transformation Optics (TO). TO enables the electromagnetic behavior of simple and conventional structures to be replicated by arbitrary geometries. Variations on traditional TO, such as quasiconformal Transformation Optics (qTO), have been developed to enable coordinate mappings to be realized with all-dielectric materials allowing for the method to be readily applied in practical GRIN lens design. However, a number of challenges arise when considering transforming traditional optical elements including replicating multi-frequency behavior and the realization of multi-element transformations. To this end, an alternative transformation procedure based on a wavefront matching (WFM) method has successfully been applied to a number of lens transformations in the optical regime. Finally, by having a suite of electromagnetic transformation procedures available, engineers are able to tackle a wide range of RF and optical problems that require or can benefit from electromagnetic wavefront manipulation.

17:50 ***Transformation Method for PTD Symmetric Edge Waveguide***

Enrica Martini (Wave Up Srl, Italy); Mario Silveirinha (Universidade de Lisboa - Instituto de Telecomunicações, Portugal); Stefano Maci (University of Siena, Italy)

This paper investigates the properties of a particular kind of edge waveguide consisting of a combination of perfect electric and perfect magnetic walls. It is shown that this waveguide supports the propagation of a mode protected against backscattering from local perturbations. The exact expression of this mode is derived through a conformal transformation approach. The protection against backscattering is a consequence of Parity-Time reversal - Duality (PTD) symmetry, which enables unidirectional propagation in reciprocal media. An example of practical implementation of this waveguide structure is also presented and numerically analyzed

18:10 ***A Geometrically Phase-Compensated Transformation Optics Superstrate for Fixed-Beam Broadband Leaky-Wave Radiation***

Loïc Markley (University of British Columbia, Canada); Asif Al Noor (University of British Columbia, Switzerland); Kyriakos Neophytou and Marco A. Antoniades (University of Cyprus, Cyprus)

We present a broadband leaky-wave antenna designed using phase-compensated transformation optics. A graded dielectric superstrate is placed above a leaky slot line to produce radiation at a fixed angle off broadside. Geometric phase compensation is applied to mitigate beam distortion due to coordinate stretching and to maintain permittivity values within a practical range.

CS43 Array Ant Design: CS43 Array Antenna Design

TOP

Future Applications / Convened Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Christophe Craeye (Université Catholique de Louvain, Belgium), Stefania Monni (TNO Defence Security and Safety, The Netherlands), Yevhen Yashchyshyn (Warsaw University of Technology, Poland)

16:30 ***Electronically Reconfigurable Metasurface Antennas Based on Liquid Crystal Technology***

Gabriele Minatti (Wave Up S. r. l. & University of Siena, Italy); Enrica Martini (Wave Up Srl, Italy); Francesco Caminita (University of Siena, Italy); Santi Concetto Pavone (Università degli Studi di Siena, Italy); Matteo Albani (University of Siena, Italy); Giovanni Toso (European Space Agency, The Netherlands); Stefano Maci (University of Siena, Italy)

This contribution proposes the use of a reconfigurable metasurfaces (MTSs) for the realization of an electronically scanning antenna for SOTM user terminals. The proposed solution is based on a periodic leaky wave (LW) structure, whose modulation period is changed dynamically to achieve beam scanning. The MTS reconfiguration mechanism is based on the use of liquid crystals (LCs). Numerical results of a preliminary design for 1D scanning are presented.

16:50 ***Cybersecurity in New Communications Systems Through 4D Array Architectures***

Paolo Rocca and Lorenzo Poli (University of Trento, Italy); Mohammad Adbul Hannan (ELEDIA Research Center, Italy); Shiwen Yang (University of Electronic Science and Technology of China (UESTC), P.R. China); Andrea Massa (University of Trento, Italy)

In this paper, an optimization-based synthesis of 4D array is performed in order to provide an additional layer of security to secure the communication signals from eavesdroppers. The security is ensured by transmitting undistorted signals along the directions of interest while maximizing the distortion elsewhere, thanks to the directional modulation (DM) characteristics of 4D array. Towards this goal, the on/off sequence of modulating pulses controlling the RF switches have been optimized by a customized strategy based on a binary Genetic Algorithm (GA). An innovative objective function based on fidelity factor (FF) which quantifies the degree of distortion as a function of angular directions is defined. Numerical and experimental results have been reported in order to validate behavior and potentialities of the proposed synthesis approach for physical layer secure communications.

17:10 ***Efficient Analysis of Arrays of Compact Metallic Elements Devoted to Satellite SAR***

Thomas Pairon and Sumit Karki (Université Catholique de Louvain, Belgium); Stefania Monni (TNO Defence Security and Safety, The Netherlands); Christophe Craeye (Université Catholique de Louvain, Belgium)

A metallic element is proposed for satellite SAR antennas and a fast analysis technique is shown to include the effects of mutual coupling. The element has some gain in the angular domain of scan and the analysis technique optimally combines multipole decompositions and macro basis functions.

17:30 ***Reduction of Mutual Coupling for Wearable Antennas***

Jiahao Zhang, Sen Yan and Xiaomu Hu (KU Leuven, Belgium); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium)

A novel metamaterial-inspired isolator which combines defected ground structures (DGS) and modified split ring resonators (SRR) is proposed. No vertical conducting parts are present, which have a risk of being broken due to user movements. It is also wideband and does not affect the compactness of the antenna array. Its most important characteristic is that it has a stable isolating performance under complex bending conditions. A prototype was fabricated and measured.

17:50 ***3D Array Element Design for Pattern Shaping***

Cristina Yepes (Delft University of Technology, The Netherlands); Erio Gandini (TNO, The Netherlands); Stefania Monni and Frank van Vliet (TNO Defence Security and Safety, The Netherlands); Andrea Neto and Daniele Cavallo (Delft University of Technology, The Netherlands)

In this work, antenna arrays with tilted dipoles are investigated in terms of radiation and impedance properties. A spectral method of moments (MoM) was developed for the analysis of doubly-periodic arrays (i.e. periodic in both x and y directions) with arbitrarily tilted dipole elements, in free space or in the presence of a backing reflector. By the aid of this analysis method, the radiation characteristics of arrays of stacked dipoles over a ground plane are studied, highlighting the variation of the patterns as a function of the inter-element distance and the angle of inclination of the elements.

18:10 ***Deep Integration Antenna Array: Design Philosophy and Principles***

Rob Maaskant (CHALMERS, Sweden); Oleg Iupikov (Chalmers University of Technology, Sweden); Corne van Puijenbroek (Eindhoven University of Technology, Sweden); Wan-Chun Liao (Chalmers University of Technology, Sweden); Marion Matters-Kammerer (Eindhoven University of Technology, The Netherlands); Marianna Ivashina (Chalmers University of Technology, Sweden)

An active integrated antenna array is designed through a new design flow called Deep Integration. Amplifier output currents are combined to synthesize the optimal antenna current distribution to produce the desired radiation characteristics. The electromagnetic field from a cluster of amplifiers is power-combined in low-loss (air) dielectrics inside a single antenna element to increase the total radiated output power. These elements can be combined in an array to further increase radiated power. Such solutions are highly compact in size and capable of delivering high Effective Radiated Power (ERP), which is particularly important in the area of mm-wave integrated circuit design for wireless applications. A simulation example is provided of a Deep Integration antenna array, demonstrating the design philosophy and principles.

Tuesday, April 2

Tuesday, April 2 8:40 - 10:20

MT_A01 Antenna Theory: MT_A01 Antenna theory, computational and numerical techniques

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Methods & Tools / Regular Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Elizabeth Bleszynski (Monopole Resesarch, USA), Grzegorz Fotyga (Gdańsk University of Technology, Poland)

8:40 ***Green's Functions of Layered Structures in Cartesian, Spherical and Cylindrical Coordinates***

Sergey Knyazev, Sergey Shabunin, Boris Panchenko and Victor Chechetkin (Ural Federal University, Russia)

The method of Green's functions of layered magneto-dielectric structures with arbitrary extraneous electric and magnetic currents is described. Specific features of the method application for Cartesian, cylindrical and spherical coordinate system are under consideration. The equivalent circuit approach is applied for layered structures description. Transmitting matrices are used for electromagnetic wave modelling in each layer and near boundaries between layers. It is shown that transmitting matrix of the boundary for flat and spherical structures is equal to the unit matrix, so equivalent electric and magnetic lines are lines are independent. The boundary matrix in cylindrical coordinates is described as 4-port matrix, and equivalent lines interact at the boundary of layers. Different kinds of loads are used for region boundaries modelling. The application of the method to solving wave propagation, antennas radiation and scattering problems is described. Structures of any number of layers, arbitrary permittivity and permeability can be considered.

9:00 ***Coupled Model for the Study of Effective Parameters of Ferroelectric Metamaterials***

Benjamin Vial (Queen Mary, University of London, United Kingdom (Great Britain)); Yang Hao (Queen Mary University, United Kingdom (Great Britain))

We study the homogenized permittivity of ferroelectric-dielectric composites under a static electric field. A rigorous numerical model is used to take into account the coupling between the electrostatic problem and the electric field dependent permittivity of the ferroelectric material. We consider metamaterial structures in two dimensions and study their effective permittivity, losses, electrically induced anisotropy and tunability.

9:20 ***Design-flow of Fabry-Perot Cavity Leaky-Wave Antennas Based on Homogenized Metasurfaces***

Silvia Tofani and Walter Fuscaldo (Sapienza University of Rome, Italy); Dimitrios Zografopoulos (CNR-IMM, Italy); Paolo Burghignoli (Sapienza University of Rome, Italy); Paolo Baccarelli (Roma Tre University, Italy); Romeo Beccherelli (Consiglio Nazionale delle Ricerche, Italy); Alessandro Galli (Sapienza University of Rome, Italy)

In this work, a design flow for leaky-wave antennas based on metasurfaces is proposed. In particular, the possibility to extract the surface impedance of partially reflecting surfaces (PRS) for which homogenization formulas are still not available in the current literature has been exploited by means of numerical tools. The knowledge of the surface impedance in a PRS-based Fabry-Perot cavity leaky-wave antenna (FPC-LWA) allows for accurately evaluating the radiating performance by means of simple analytical formulas. To validate the proposed approach, a fishnet-like metasurface is designed and its implementation as a partially reflective sheet for a highly-directive FPC-LWA working at terahertz frequencies is discussed.

9:40 ***Macromodels for Efficient Analysis of Open-Region Problems Using the Finite Element Method***

Damian Szypulski (Gdansk University of Technology, Poland); Martyna Mul (Gdańsk University of Technology, Poland); Krzysztof Nyka (Gdansk University of Technology, Poland); Grzegorz Fotyga (Gdańsk University of Technology, Poland)

This paper presents a local model-order reduction, called macromodeling, applied to speed-up the simulations of open-region problems, analyzed by means of finite element method. This technique is illustrated by a numerical example, which deals with a dielectric resonator antenna (DRA). The obtained results show that the proposed approach is reliable and can significantly increase the standard finite element method efficiency.

10:00 ***A Method of Moments for Vertical Currents in Stratified Media with Reaction Integrals Directly in the Spectral Domain***

Harshitha Thippur Shivamurthy and Andrea Neto (Delft University of Technology, The Netherlands)

A novel procedure to evaluate the reaction integrals for the Method of Moments (MoM) solution of problems containing vertical currents in stratified media is discussed. The novelty lies in performing the reaction integrals directly in the spectral domain. The procedure is expected to be competitive in terms of computational time as the vertical integrations can be performed analytically with appropriate choice of basis and testing function.

Tuesday, April 2 8:40 - 12:30

CS23 Future Space Missions: CS23 Antenna needs and solutions for future Space missions

TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France), Hervé Legay (Thalès Alenia Space, France)

8:40 ***Recent MDA Antenna Technology for Very High Throughput Satellite***

Jaroslaw Uher and Arnaud Maillard (MDA Space Missions, Canada); Jonathan Hill (MDA Corporation, Canada); Michael Aliamus (Space Systems/Loral, USA); Stephane Lamoureux, Dino Kefallinos and Mark Fontaine (MDA Space Missions, Canada); Eric Amyotte (MDA, Canada)

Recent MDA advancements in the area of high performance, low cost compact feed chains to be applied in very high throughput satellite antennas are described. The feed chain design methodology is outlined and performances of selected feed types are presented.

9:00 ***Estimation of near Field Distribution of Seven Panels of Parallel Plate Slot Arrays for a 100Kg-Class X-band SAR Satellite***

Jiro Hirokawa and Takashi Tomura (Tokyo Institute of Technology, Japan); Prilando Rizki Akbar (Institute of Space and Astronautical Science-Japan Aerospace Exploration Agency, Japan); Budhaditya Pyne (University of Tokyo, Japan); Hirobumi Saito (Institute of Space and Astronautical Science-Japan Aerospace Exploration Agency, Japan)

We have developed a SAR sensor compatible with 100kg-class satellites. This paper estimates the near field distribution of seven panels of parallel plate slot arrays for this satellite, by connecting the measured near field distributions of the panels with weighting properly by the measured scattering matrices of the panels.

9:20 ***NISAR Flight Feed Assembly: Evolution of the Design from Initial Concept to Final Configuration***

Paolo Focardi (Jet Propulsion Laboratory & California Institute of Technology, USA)

NISAR (NASA ISRO SAR, National Aeronautics and Space Administration, Indian Space Research Organization, Synthetic Aperture Radar) is an Earth science project currently in its final development phase at NASA Jet Propulsion Laboratory (JPL) and at ISRO. Due for launch in 2022 it will assess how our planet changes overtime by measuring differences in the Earth's solid surface due to factors like climate change, movement and melting of glaciers, earthquakes, land-slides, deforestation, agriculture and others. The enabling instrument for this mission is a dual band radar (L-Band and S-Band) that feeds a 12m deployable mesh reflector. This paper describes the evolution of the L-Band feed design from its initial concept to the final flight configuration. Two major aspects of the design are discussed in this paper: the TNC connector configuration and the upper patch attachment mechanism.

9:40 ***Planar Wide-Scan Wideband Phased Arrays with Improved Polarization Purity***

Daniele Cavallo (Delft University of Technology, The Netherlands)

One of the common requirements for wideband wide-scanning arrays in multi-functional platforms is the polarization agility. Cross-polarization levels should be kept low within the entire field of view and frequency band of operation. However, good polarization purity is hard to achieve especially for arrays that are designed to operate over multi-octave bandwidth. Planar wideband array often use dielectric slabs above the antenna aperture to improve the matching while scanning and increase the front-to-back ratio. However, dielectric superstrate deteriorate the polarization performance on the diagonal planes. The characteristic cross-polarization of a connected slot array in the presence of artificial dielectric layers superstrates is analyzed. An approach to reduce the cross-polarization is then investigated, consisting of localizing the artificial dielectric only in specific regions of the unit cell, rather than on the entire area.

10:00 ***Compact Antennas for Nano- And Micro- Satellites: Development and Future Antenna Needs at CNES***

Baptiste Palacin, Romain Contreres, Anthony Bellion, Rémi Fragnier, Kevin Elis and Vincent Laquerbe (CNES, France)

CNES started developments on miniaturized antennas for small platforms in 2010s (spectrum survey, MASCOT lander). More recently, compact and wideband antennas for TT&C were designed, manufactured and tested for cubesats needs. Over the last two years, besides the development of Angels nanosatellite, a demonstrator of Argos miniaturized technologies, CNES has supported several activities on this topic. Resulting antenna designs and performances are briefly presented in this paper. Finally, new challenges and perspectives for cubesats antennas, as envisioned by CNES, are discussed.

10:20 Coffee Break

10:50 ***Design of Dual-Band Dual-Polarized Reflectarray for Future Multiple Spot Beam Applications in Ka-band***

Min Zhou, Stig Sørensen, Niels Vesterdal and Michael F. Palvig (TICRA, Denmark); Yan Brand, Simon Maltais and Jordan Bellemore (MDA, Canada); Giovanni Toso (European Space Agency, The Netherlands)

The design of a parabolic polarization selective reflectarray for dual-band dual-circular polarization for multiple beam applications in Ka-band is presented. The reflectarray has a diameter of 0.65 m and is a single-layer design consisting of rotated split hexagonal-loop dipole elements. For RHCP, the reflectarray scans the reflected beam half a beamwidth in one direction, and for LHCP, the reflectarray scans the reflected beam half a beamwidth in the opposite direction. This is achieved in both Tx (19 GHz) and Rx (29 GHz). Using a feedarray of 27 feeds, 54 beams can be generated. With this concept, a full multiple beam coverage employing the 4-color frequency/polarization reuse scheme can be covered using only two reflectarrays while maintaining the single-feed-per-beam operation.

11:10 ***The Water Drop Lens: a Low-Profile Geodesic Parallel Plate Waveguide Lens Antenna for Space Applications***

Nelson Fonseca (European Space Agency, The Netherlands); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This paper introduces the design of a parallel plate waveguide geodesic lens modulated with spline functions. This geodesic lens design is rotational-symmetric, which naturally provides a high pattern stability over a wide angular range. The proposed design is thoroughly compared to the reference Rinehart-Luneburg lens and numerical results indicate similar electromagnetic performance, including scattering parameters and radiation, while enabling a height reduction by a factor of 2.6. This beamformer provides very wide angular scanning up to ±70° with scan losses below 3 dB. The lens can be designed to provide very high aperture efficiency (between 80 and 90%) over a wide frequency operating range. Analyses were performed over the frequency range 26-32 GHz, demonstrating very stable performance. The very smooth shape of the lens is particularly attractive for applications at millimeter and sub-millimeter wavelengths.

11:30 ***Design of a Compact Four-Way Dual Polarization Orthomode Power Divider for Multiport Radiating Elements***

Charalampos Stoumpos (Thales Alenia Space)

The concept and design of a novel compact power divider exhibiting dual-polarization and its use as a feeder for a Fabry-Perot cavity antenna comprising 4 input ports is presented. The dual and in-phase polarization on each of the four circular waveguides is achieved by using 4 five-port turnstile junctions accompanied by two 8-by-1 power division structures. The power divider ends up to two ports (each for one polarization) so that it can be used as a feeding network for an antenna array. The design is fully metallic, a feature that makes this feeder an ideal candidate for satellite applications. The design band is 3.65 to 3.95 GHz, presenting a Return Loss better than 20 dB and an input-output isolation (orthogonal modes) better than 30 dB. The exciter is further connected to Fabry-Perot cavity antenna and the simulation results of the total feed are presented.

11:50 ***Structural Solutions of Deployable Antennas for Small Satellites***

Leri Datashvili, Nikoloz Maghaldadze and Louis Dufour (Large Space Structures GmbH, Germany)

With the generalization of the use of small satellites for Earth observation and telecommunication missions, there is an increasing need for deployable antennas for small platforms, and in particular deployable reflector antennas. This paper present different research and development focuses in the field of small densely stowable reflector designs, with precision allowing their use up to Ka-band.

12:10 ***A New Double Polarization Isoflux Antenna***

Gabriele Minatti (Wave Up S. r. l. & University of Siena, Italy); Francesco Caminita (University of Siena, Italy); Enrica Martini (Wave Up Srl, Italy); Rodolfo Ravanelli (Thales Alenia Space Italy SpA, Italy); Paolo Campana (ThalesAleniaSpace-Italia, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Stefano Maci (University of Siena, Italy)

This paper provides the results of an activity framed in a GSTP contract financed by the European Space Agency aimed at the design of an X-band antenna for data downlink (DDL) from LEO satellites. These antennas typically have an isoflux radiation pattern and operate in dual circular polarization. The proposed solution is a fully metallic low profile antenna based on an equivalent impedance surface realized by concentric corrugations and fed by a low profile feeding system. In this paper, we first introduce the requirements according to which the antenna has been designed, and then present the designed antenna along with a comparison between numerical and experimental results.

CS1 Unconv Techn Inv Scatt: CS1 Unconventional techniques and applications for inverse scattering problems

TOP

Future Applications / Convened Session / Propagation

Room: Oral Sessions: S3-A – Gdansk

Chairs: Martina Teresa Bevacqua (Università Mediterranea di Reggio Calabria, Italy), Lorenzo Crocco (CNR - National Research Council of Italy, Italy)

8:40 ***Three-Dimensional Microwave Imaging by Using a Conjugate-Gradient Approach in Lp Banach Spaces***

Claudio Estatico, Alessandro Fedeli, Matteo Pastorino, Andrea Randazzo and Emanuele Tavanti (University of Genoa, Italy)

An inverse scattering procedure for addressing three-dimensional microwave imaging problems is presented in this paper. The approach is based on the full-vector integral formulation of the scattering phenomena and exploits the regularization capabilities of a Newton scheme integrating a conjugate-gradient approach developed in L^p Banach spaces. An initial performance assessment of the proposed imaging algorithm, obtained by using numerically simulated data, is reported.

9:00 ***Experimental Investigation of Microwave Imaging as Means to Assess Fruit Quality***

Navid Ghavami (King's College London); Ioannis Sotiriou and Panagiotis Kosmas (King's College London, United Kingdom (Great Britain))

The continuous increase in global food consumption brings forward the need for constant development of technologies to enhance the existing quality assessment methods in order to both increase the safety of the consumers and decrease the product wastage. In recent decades, microwave imaging has emerged as a promising non-invasive and non-ionizing technology for a range of applications. In this paper, the applicability of a newly developed microwave radar algorithm for fruit imaging is proposed. The measurements have been performed using purpose built hardware and the image reconstruction has been performed through a Huygens principle based algorithm. The variation in the dielectric properties of the fruits' internal body allows the algorithm to detect and capture the contrast when reconstructing their internal field. Experimental results on lemons and grapefruits indicate the capability of the algorithm to both detect seeds inside the fruits and distinguish between seeded and seedless samples.

9:20 ***Inverse Profiling for Microwave Diagnostics of ECR Ion Source Plasma***

Loreto Di Donato and Gino Sorbello (University of Catania, Italy)

Electron cyclotron resonance (ECR) plasma diagnostics is one of the main challenging research activity in plasma physics due to the extraordinary possibility to gain information about the heating and fusion process both in small size and large size reactors. Among the other possibilities, microwave imaging offer an interesting way to retrieve the shape and the electron density/collision rate distribution. With reference to such a scenario, we address the problem of reconstructing one dimensional plasma electromagnetic profile via inverse scattering technique, processing multifrequency reflected data gathered under a relatively simple wide frequency sensing apparatus.

9:40 ***Recent Advances in Matrix Completion Techniques as Applied to Tomographic Imaging***

Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Marco Salucci and Nicola Anselmi (ELEDIA Research Center, Italy); Andrea Massa (University of Trento, Italy)

Innovative inversion methodologies exploiting the paradigm of Bayesian Compressive Sensing (BCS) have been successfully introduced in the last few years to address sparse and linear microwave imaging problems. Their success is motivated by several concurring factors, including their capability to estimate the "confidence level" of the obtained inversions. Despite the informative content associated to such estimations, confidence maps have been mostly used to assess the quality of microwave images rather than to enhance it. The possibility to integrate rank-minimization techniques with BCS imaging strategies, recently introduced in the framework of Matrix Completion Inversion, will be reviewed in this work. Selected numerical examples considering a Born formulation of the tomographic microwave imaging problem will be presented to illustrate the features and capabilities of the arising techniques.

10:00 ***Dealing with Correlation and Sparsity for an Effective Exploitation of the Compressive Processing in Electromagnetic Inverse Problems***

Nicola Anselmi (ELEDIA Research Center, Italy); Lorenzo Poli (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri, Paolo Rocca and Andrea Massa (University of Trento, Italy)

In this paper, a novel method for tomographic microwave imaging based on the Compressive Processing (CP) paradigm is proposed. The retrieval of the dielectric profiles of the scatterers is carried out by efficiently solving both the sampling and the sensing problems suitably formulated under the first order Born approximation. Selected numerical results are presented in order to show the improvements provided by the CP with respect to conventional compressive sensing (CSE) approaches.

10:20 Coffee Break

10:50 ***A Numerical Study on Optimal Multipole Order for Sparse Microwave Imaging of Star-Shaped Scatterers***

Marija Nikolic and Nebojsa Vojnovic (University of Belgrade, Serbia); Lorenzo Crocco (CNR - National Research Council of Italy, Italy)

In this paper, we extend the work on higher-order sparse two-dimensional microwave imaging using transverse magnetic polarized fields. This approach is capable of retrieving the shape of concave targets, which is particularly interesting when imaging complex targets. However, the performance of the approach is affected by the considered multipole order. Accordingly, in this communication we report a numerical study dealing with the imaging of star-shaped objects, aimed at determining which is the optimal multipole order that can be solely used to successfully image the target, depending on its electrical size.

11:10 ***Inverse Design of Multibeam GAMs-based Lens Antenna***

Roberta Palmeri (Università Mediterranea of Reggio Calabria, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

The synthesis of graded artificial materials (GAMs) based antennas is attained as solution of an inverse scattering problem wherein a proper representation basis for the unknown is exploited. To this aim, the data of such a problem are represented by some desired radiation specifications for the lens. In particular, in this contribution the design of a GAMs based lens able to accommodate multibeam radiation is carried out.

11:30 ***RCS Estimation by Single Frequency Near-field Data***

Tushar Ranivanshi (Università della Campania, Italy); Angela Dell'Aversano (Seconda Università degli Studi di Napoli, Italy); Giovanni Leone (Università della Campania Luigi Vanvitelli, Italy); Raffaele Solimene (Università degli studi della Campania Luigi Vanvitelli, Italy)

Radar Cross Section (RCS) is a far-field quantity that describes the scattering ability of a target across the different directions. Nonetheless, for a number of reasons, it is convenient to use near-field data for RCS estimation. In this contribution, an imaging based method for monostatic RCS estimation is considered. In particular, a comparison between single-frequency and multi-frequency near-field data is presented.

11:50 ***Frequency-Diverse Computational Polarimetic Imaging***

Okan Yurduseven (NASA Jet Propulsion Laboratory, California Institute of Technology & Duke University, USA); Thomas Fromenteze (XLIM, Université de Limoges, France); Rixi Peng and David Smith (Duke University, USA)

In this paper, a frequency-diverse computational polarimetric imaging system is demonstrated at K-band (17.5-26.5 GHz) frequencies. The frequency-diverse operation enables all-electronic data-acquisition by means of a simple frequency-sweep and requires no mechanically moving apparatus or phase shifting circuits for imaging. Leveraging a tensor model for the scattering behavior, as opposed to a scalar model, enables the extraction of further information from the imaged objects. This is shown by means of frequency-diverse polarimetric imaging of complex objects, such as the letters of the word "DUKE", and comparing the reconstructed polarimetric images to the reflectivity-only reconstructions of the same objects.

12:10 ***A Feasibility Study of a Microwave Imaging Device for In-Line Food Contamination Monitoring***

Laura Farina (National University of Ireland Galway & CURAM, Ireland); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Jorge Alberto Tobon Vasquez and Javier Rivero (Politecnico di Torino, Italy); Amélie Litman (Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France); Francesca Vipiana (Politecnico di Torino, Italy)

Food quality is of a huge interest for food industry. In particular, the presence of small foreign fragments is generally the main issue in food quality control. While metal detectors can assess the presence of metal contaminants, they fail in detecting plastic or glass fragments. Hence, the use of microwave imaging system to be used along the production chain is proposed in this work. This scenario implies a reduced time for data gathering and hence a limited amount of available data. To face this issue, an imaging system taking advantage of the target's movement and of the expected small size of the sought contamination is developed. In this communication, the basic idea of the approach is described and assessed in a simple (although meaningful) case.

Tuesday, April 2 8:40 - 10:20

F_M04 Anal & Proc Ant Meas Data: F_M04 Effective Analysis and Processing of Antenna Measurement Data

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Future Applications / Regular Session / Measurements

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Dennis Lewis (Boeing, USA), Janet O'Neil (ETS-Lindgren, USA)

8:40 ***Mitigation of Band Edge Effects in Fourier Transform Based Time Domain Gating***

Zhong Chen (ETS-Lindgren, USA)

Time domain gating is a well-known signal processing technique by first converting frequency domain data to time domain via inverse Fourier Transform. Time domain gating is thereafter applied as a filter to include or exclude certain time periods. One of the side effects of time domain gating is band edge effects where data near band edges are unreliable. Several mitigation techniques have been reported and implemented in commercial vector network analyzers, namely pre-gate windowing and post-gate renormalization. Even after applying these mitigation techniques, the errors can still be significant. In this paper, we summarize these common mitigation techniques, and introduce a novel Spectrum Extension Edgeless Gating (SEEG) method. In SEEG, frequency domain data is first extended beyond the edges smoothly, and time domain gating is applied over the extended data. In a wide range of antenna measurement applications, SEEG method is shown to be superior for reducing uncertainties from the edge effects.

9:00 ***Measurement Field Source for Antenna Placement in Space Applications***

Lucia Scialacqua, Maria Alberica Saporetti, Francesco Saccardi and Lars Foged (Microwave Vision Italy, Italy); Jan Zackrisson (RUAG Space AB, Sweden); Damiano Trenta (European Space Agency, ESTEC, Italy); Luca Salghetti Drioli (European Space Agency-ESTEC, The Netherlands)

Measured antennas as field sources in numerical simulation is by now a consolidated method to investigate deployed antenna performance. Typical applications are situations where a measurement of the entire scenario or a full-wave representation is unfeasible or unavailable [1-5]. Antenna placement on complex platforms such as satellites are good examples of such application. In these scenarios, the antennas are often supplied by a third party. Thus the mechanical and electronic characteristics needed for a full-wave representation of the antenna are likely unavailable or not in the right format for use by the Computational Electromagnetic (CEM) tool. To overcome this problem, the antenna can be fully characterized by measurement. The equivalent field source, compatible with the CEM tool, can then be derived, as a Huygens box, using an Equivalent Current (EQC) expansion [6-7]. The measured field source was applied in the investigation of a GNSS antenna on a mock-up of the Sentinel satellite designed, manufactured and measured by RUAG SPACE [8]. This scenario was investigated in [9-10]. In this paper, the accuracy investigation is extended to include different CEM tools [11-12] and comparison with measurements of the full mock-up.

9:20 ***Antenna Calibration Based on Near-Field to Far-Field Transformation Algorithms***

David Ulm, Thomas Kleine-Ostmann and Thorsten Schrader (Physikalisch-Technische Bundesanstalt, Germany)

Antenna calibration is classically performed assuming far-field conditions. With increasing computational power available, numerically demanding near-field to far-field transformation algorithms are becoming more important. This paper shows how modern near-field to far-field transformation algorithms can be used to precisely calibrate antennas. In addition to the actual algorithm, this paper also demonstrates how the calculated far-field data can be used to calculate the electric field strength in front of arbitrary antennas. This post processing step is of special importance for the traceable calibration of electric field strength meters.

9:40 ***Low-Uncertainty Characterization of a Predictable Active and Broadband Antenna***

Carlo Carobbi and Andrea Guadagnoli (University of Florence, Italy)

A detailed description of the calibration of a wideband reference electromagnetic field radiator consisting of the combination of a comb generator and a biconical antenna is offered. Calibration is based on the joint use of measurements of the comb generator power and simulations of the biconical antenna radiation parameters. An original aspect of the contribution is the quantification of uncertainty of both the comb generator power measurement and electromagnetic field prediction. Evidence of the validity of the uncertainty quantification is provided by a comparison between far-field measurements and predictions.

10:00 ***Comparison of Source Localization and Scatterer Modeling in Near-Field Antenna Measurements***

Alexander Paulus, Jonas Kornprobst, Raimund A. M. Mauermayer and Thomas F. Eibert (Technical University of Munich, Germany)

The accuracy of near-field antenna measurements combined with near-field far-field transformations (NFFFT) is deteriorated if objects are located in close vicinity to the antenna under test (AUT). We compare two equivalent sources based modeling techniques to suppress the influence of structures in the vicinity of the AUT. Simulation results for perfect electrically conducting objects showcase the capabilities and limitations of both approaches. The presented methods can easily extend existing NFFFTs in order to remove the influence of mounting structures or parts of the positioning system in anechoic near-field measurement facilities.

C_M01 MIMO & OTA testing: C_M01 MIMO and OTA testing

TOP

Cellular Communications / Regular Session / Measurements

Room: Oral Sessions: S4-A - Poznan

Chairs: Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden), Gerald Artner (Vienna University of Technology, Austria)

8:40 ***Design of Dual Polarised Wide Band Plane Wave Generator for Direct Far-Field Testing***

Francesco Scattone (Microwave Vision Group (MVG), Italy); Darko Sekuljica (MVG, Italy); Andrea Giacomini, Francesco Saccardi and Alessandro Scannavini (Microwave Vision Italy, Italy); Nicolas Gross and Evgueni Kaverine (MVG Industries, France); Per Iversen (Orbit/FR, USA); Lars Foged (Microwave Vision Italy, Italy)

The Plane Wave Generator (PWG) is intended to generate a local plane wave in its close proximity. It consists of an array of elements with optimized complex excitation and disposed on a suitable lattice. The PWG achieves far-field testing condition in a spherical Quiet Zone (QZ) where the antenna under test (AUT) can be directly measured. The testing method is similar to a Compact Antenna Test Range (CATR), but a considerably smaller space is required. Early PWG designs have been limited to narrow-band and single polarization. In this paper we present the design and measured performance of a dual-polarized PWG with 10:1 bandwidth. The prototype has been tested in the 0.6-6 GHz frequency range. In the following, we show the initial testing results on the QZ uniformity and an initial evaluation of the achievable measurement accuracy.

9:00 ***Test Zone Verification Procedures in a Random-LOS Measurement Setup***

Madeleine Schilliger Kildal (Chalmers University of Technology & RanLOS AB, Sweden); Aidin Razavi (Ericsson Research, Ericsson AB, Gothenburg, Sweden); Jan Carlsson (Provinn AB, Sweden); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

In this paper we analyze three different verification procedures of the test zone in the Random Line-of-Sight measurement setup. The goal is to find a way to reduce the number of samples needed to estimate the standard deviation and the mean value within a circular test zone. It was found that more than 50 samples are needed to get reliable performance with the verification procedure using two orthogonal lines. However all three investigated methods work well, but the two other methods need more than 100 samples. This means that the samples can be taken within the test zone along two orthogonal lines, in a spiral shape, as well as a combination of these two methods, depending on the user's preference.

9:20 ***Beam Probability Metric for OTA Testing of Adaptive Antenna Systems in Multi-Probe Anechoic Chamber Setups***

Huaqiang Gao (Beijing University of Post and Telecommunication, P.R. China); Weimin Wang (Beijing University of Posts and Telecommunications, P.R. China); Wei Fan (Aalborg University, Denmark); Yongle Wu (Beijing University of Posts and Telecommunications, P.R. China); Yuanan Liu (Beijing University of Posts and Telecom, P.R. China); Gert Pedersen (Aalborg University, Denmark)

With the utilization of massive multiple-input multiple-output (MIMO) and millimeter-wave (mmWave) technologies in 5G communications, over-the-air (OTA) testing for 5G antenna systems has become a strong need because conducted testing is no longer applicable. New OTA testing metrics are required to evaluate new performance of 5G antenna systems. This paper investigates whether the recently proposed metric, e.g. beam probability is suitable to evaluate channel emulation accuracy for adaptive antenna systems in multi-probe anechoic chamber (MPAC) OTA setups. Well-known 2D spatial channel models are selected as examples in simulation results to discuss the relationship between device under test (DUT) size and number of OTA antennas for beam probability metric.

9:40 ***Plane Wave Synthesis with Irregular Chamber Planar Antenna Arrays for Compact OTA Measurements***

Mohammad Poordaraee (University of Twente, The Netherlands); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

There is an increasing demand to develop advanced very large antenna systems, especially for the new 5G wireless networks. Over-The-Air (OTA) testing techniques need to meet the challenges arising from the large size and complexity of the massive multi-element array antennas. In the Random-LOS (Line-of-Sight) OTA measurement setup, a plane wave is emulated in the test zone which is also in the near-field of the anechoic chamber antenna used to emulate the far-field from a base station. In this paper, the thinned array antenna concept is applied to synthesize a plane wave within the test zone of the OTA setup. The thinning is performed by means of the Genetic Algorithm. Two planar array antenna configurations are considered for emulating a plane wave for 2D and 3D test zones at 2.7 GHz. The optimized thinned array achieves a 55% reduction of the number of antenna elements. Smaller amplitude and phase fluctuation are observed in the test zone in comparison to other arrays of similar aperture.

10:00 ***Testing Antenna Chip-Sets Under Thermal Conditions***

Per Iversen (Orbit/FR, USA); Edward Szpindor, Wenji Zhang and Michael Roseborough (MVG-Orbit/FR, Inc, USA)

The wireless community is concerned with proper operation of devices over wide temperature ranges, and as such the governing bodies are imposing radiated test requirement at hot and cold temperatures. These requirements become unique when new radio technologies are highly integrated, and the antenna is embedded on a chip or chip-set, or in packaged devices. The challenge starts with achieving junction temperatures from -30C to +90C while reaching the desired temperatures quickly and holding the temperature extremes for extended periods of time. The temperature change causes thermal expansion of antenna materials and may affect antenna performance under different thermal conditions. Furthermore, efficient heating and cooling is environmentally responsible and reduces lab power and HVAC costs. It also increases the longevity and safety of the device during field use. The goal is to measure antenna and digital radio quality metrics under these conditions, while providing minimal perturbation of the beam. The paper presents a solution meeting these requirements and which has already deployed in industry. Performance data will also be presented. The users of the deployed systems continue to push for more temperature range and field of view of the measurement system. R&D efforts underway as well as future work will conclude the paper. Index Terms-antenna, integrated antennas, 5G, temperature test, measurement.

CS28 Channel Modelling Railway Env 5G: CS28 Channel modelling in railway environments for 5G applications

TOP

Cellular Communications / Convened Session / Propagation

Room: Oral Sessions: S4-B - Lublin

Chairs: Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain), Juan Moreno García-Loygorri (Technical University of Madrid, Spain)

8:40 ***Channel Sounding and Ray Tracing for Train-to-Train Communications at the THz Band***

Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany); Bile Peng (Chalmers University of Technology, Sweden); Danping He and Dong Yan (Beijing Jiaotong University, P.R. China); Bo Ai (Beijing Jiaotong University & State Key Lab of Rail Traffic Control and Safety, P.R. China); Zhangdui Zhong (Beijing Jiaotong University, P.R. China); Thomas Kürner (Technische Universität Braunschweig, Germany)

In order to increase railway capacity for passengers and freight, it is necessary to realize virtual coupling technology through train-to-train (T2T) communications. This T2T link requires large bandwidth for high-data rate and low latency, forming a strong motivation to explore terahertz (THz) band. In this paper, the T2T channel is characterized through ultrawideband (UWB) channel sounding and ray tracing at THz band for the first time. To begin with, a series of T2T channel sounding measurements are performed in a train test center at 300 GHz with 8 GHz bandwidth. Correspondingly, Rician K-factor and root-mean-square (RMS) delay spread are extracted from the measured power-delay profile (PDP). After validated by the measurements, a self-developed ray-tracing (RT) simulator is used to physically interpret the propagation mechanism constitution and significant objects in the target scenario. This provides the first hand information of how the communicating trains themselves influence the T2T channel, and therefore, lays the foundation for channel modeling through extended RT simulations in the future.

9:00 ***Joint Delay and Doppler Frequency Estimation for Scatterer Localization in Railway Environments***

Paul Unterhuber, Michael Walter and Nicolas Schneckenburger (German Aerospace Center (DLR), Germany); Thomas Kürner (Technische Universität Braunschweig, Germany)

Autonomous driving vehicles shall increase the efficiency of passenger and goods transportation. Connecting these vehicles and ensuring the reliable exchange of safety critical data is one of the biggest challenges nowadays. The basis of reliable communication between vehicles is a fundamental understanding of the propagation mechanism and the resulting channel models. For the communication between moving vehicles geometry-based stochastic channel models (GSCMs) are widely used to model the non-stationary channel processes. To understand the underlying geometry between transmitter, receiver and scatterers, we propose a joint delay and Doppler frequency estimation to localize scatterer. We use train-to-train (T2T) measurement data and estimate the delay and the Doppler frequency for each measurement of each received signal. The probability density function (PDF) of the joint delay and Doppler frequency estimation is transformed to the Cartesian domain and plotted on a geo-referenced satellite image. In this way, the estimated scatterer position and the related propagation characteristics can be assigned to real objects.

9:20 ***Dynamic Train-to-Train Propagation Measurements in the Millimeter Wave Band - Campaign and First Results***

Mohammad Soliman (Deutsches Zentrum für Luft- und Raumfahrt, Germany); Paul Unterhuber, Stephan Sand and Emanuel Staudinger (German Aerospace Center (DLR), Germany); Jeries Shamshoom and Christian Schindler (RWTH Aachen University, Germany); Armin Dekorsy (University of Bremen, Germany)

In this paper, we describe a dynamic train-to-train (T2T) millimeter wave (mmWave) propagation measurement campaign to enable the automatic train coupling application. mmWave frontends with directive antennas were installed on the couplers of two trains where the channel impulse response was recorded throughout the measurements. The campaign covered more than 30 recorded measurements in different environments. Received signal power in the open field area was analyzed and modeled using a two-ray pathloss model. Furthermore, received power next to the platform was higher compared to the open field counterpart due to strong contributions from the signals reflected by the platform. Distance estimation accuracy between the transmitter and the receiver using a snapshot based estimator was evaluated and an accuracy of 55 cm could be achieved in more than 99.73% of the time.

9:40 ***Saleh-Valenzuela Modelization and Clustering Information for a Mmwave Intra-Train Channel***

Juan Moreno (Universidad Politécnica de Madrid, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Antonio Perez Yuste (Technical University of Madrid, Spain)

The connected train is one of the key scenarios for 5G mobile communications. The reason is clear: providing connectivity on an ultra-dense environment in mobility is a double challenge (high-speed trains can go up to 350 km/h and metro trains are able to carry more than 1000 people in a 100 meters-long train). The spectrum below 6 GHz is crowded and the opportunity comes from mmwave band. This paper analyzes the intra-train channel at 26.5-40 GHz using a VNA, taking measurements at 5 different distances, 4 angles and two type of antennas. The outcome of this experiment is the PDP on each scenario, multipath clusters and Saleh-Valenzuela modelization of the channel. Differences between the scenario with and without people are explained as well

10:00 ***Smartphone-based Measurements On-Board FSS-aided Railway Vehicles***

Taulant Berisha and Christoph F Mecklenbräuker (Vienna University of Technology, Austria)

It is obvious that railway environments are gaining interest due to their social and economical impact. Today, the main challenge towards seamless connectivity over mobile communications on-board railway vehicles stems from as high as some tens of decibels vehicle penetration loss. To cope with it, frequency selective surfaces are quickly gaining ground as an alternative solution to replace railway vehicle's standard windows which only guarantee protection against infrared and ultraviolet rays. In this study, we performed smartphone-based measurements on-board high speed train with frequency selective surfaces. The experiments were conducted with target to mimic quasi-real usage of end users. All in all, we first evaluated the performance of key performance indicators based on smallscale measurements and then applied nonparametric inferential statistics to assess the service quality of end users in various vehicle placements.

CS13 Ant on IoT: CS13 Antennas on IoT applications

TOP

Localization & Connected Objects / Convened Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France), Yue Gao (Queen Mary University of London, United Kingdom (Great Britain))

8:40 ***Ultra Miniature Antenna Design Using LDS Technology***

Jean-François Pintos and Cherif Hamouda (CEA-LETI, France)

This paper deals with the design of an ultra-miniature antenna (ka~0.2) for pager communication at 170 MHz. The design is based on a loaded loop printed antenna along the outside of the plastic cover, the load and matching circuits are located on a Printed Circuit Board (PCB) placed inside the pager. The Laser Direct Structuring (LDS) technology is used to print the antenna on plastic cover. Obtained results show a bandwidth of 1.2 MHz, a maximum realized gain of -12 dBi and a radiation efficiency around 4 %.

9:00 ***Directive Dual-Band Fabry-Perot Cavity Antenna for 5G-IoT Near-Ground Communications***

Hicham Klaina (University of Vigo, Spain); Badreddine Ratni (Univ Paris Nanterre, France); Ana Alejos (Universidade de Vigo, Spain); Otman Aghzout (ENSA Tetouan - UAE, Morocco); Shah Nawaz Burokur (LEME, France)

This paper describes the design of a directive low-profile dual-band Fabry-Perot cavity antenna with narrow beamwidth. The antenna is designed for near-ground wireless sensor network operating at the frequency bands of 2.4 GHz and 5.8 GHz, intended for smart agriculture applications. The proposed structure consists of an excited patch radiating element used as a primary feed embedded between two parallel reflectors; a perfect reflector and a bi-layered partially reflecting surface (PRS) consisting of both capacitive and inductive grids. Aiming to reduce and suppress radiation in undesired directions, four metallic walls are added to the lateral sides of the cavity leading to an improvement in directivity. The simulation results demonstrate a high directivity, low secondary lobes level and narrow beamwidth in both elevation and azimuth planes for both frequency bands. These features ensure an optimal performance of an antenna for working in near-ground environments.

9:20 ***Compact Antenna for Diversity Applications Based onCharacteristic Modes***

Eva Antonino-Daviu (Universitat Politècnica de València, Spain); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Miguel Ferrando-Bataller (Universitat Politècnica de València, Spain)

This paper presents the design of a miniature reconfigurable pattern antenna based on characteristic mode analysis. The fundamental mode analysis of a 80 mm x 54 mm rectangular plate is realized at 1.575 GHz to identify the modes that can be used. A solution based on the excitation in the four corners of the plate is proposed and simulated.

9:40 ***Antenna/Radio Matching Technique for Certified Multi-module IoT Devices***

George Shaker (University of Waterloo & Spark Tech Labs, Canada); Perry Jarmuszewski and George Mankaruse (Spark Tech Labs, Canada)

To save production costs, simplify software development, accelerate certification cycles, and achieve faster time-to-market, many internet of things (IoT) devices resort to using a module-based design. However, a device involving multiple wireless modules may suffer from antenna/radio frequency issues that can result in failing to obtain standard system certification. This paper demonstrates an antenna matching technique applied to a real-world IoT device where no post-production antenna/matching was permitted to the integrated wireless modules.

10:00 ***Solar Cell Antenna for IoT and Wearble Applications***

Alexander Vorobyov (CSEM & Center Suisse d'Electronique et de Microtechnique SA, Switzerland); Cedric Hennemann and Philippe Dallemagne (CSEM, Switzerland)

In this paper a promising photovoltaic cell antenna solution for IoT and wearable applications is presented. In the proposed solution no physical modification of the photovoltaic cell is needed. The photovoltaic cell metallic components is used as an antenna part for a radio frequency (RF) transceiver. Prototyped antenna has been characterized in lab environment. The antenna is well matched at 1.5GHz.

R_M01 Radar Scattering: R_M01 Radar Scattering Measurement and Calibration Techniques

TOP

Radars / Regular Session / Measurements

Room: Oral Sessions: S4-D - Bytom

Chairs: Genevieve Maze-Merceur (CEA, France), Adam Narbudowicz (Wroclaw University of Science and Technology, Poland & TU Dublin, Ireland)

8:40 ***Radar Reflectivity Spatial Profile of 3D Surrogate Targets and Real Vehicles***

Henrik Toss and Kristian Karlsson (RISE Research Institutes of Sweden, Sweden)

In this paper a method to find a radar reflectivity spatial profile for comparing 3D surrogate targets with real vehicles is proposed. For data within a small angular window at arbitrary Angle of Arrival (AoA) relative to the target, the proposed method back-projects Radar Cross Section (RCS) detections, to build up a spatial profile. This profile can then be used to evaluate multiple scattering centers on targets, which are important during test of autonomous vehicles and active safety functions. In future work bounds could possibly be added to the spatial profile, as a complementing procedure during certification. The method is used on measured data from 3D surrogate targets as well as real vehicles, which are presented in the paper.

9:00 ***Reducing Influence from Ground Reflection During RCS Characterization of Automotive Targets***

Kristian Karlsson and Henrik Toss (RISE Research Institutes of Sweden, Sweden); Francesco Costagliola (Volvo Car Corporation, Sweden)

Ground reflection is the major contributor to measurement uncertainty in the characterization of Radar Cross-Section (RCS) of automotive targets. In this paper we present a study of the influence of ground reflection on RCS measurements of large targets - such as real vehicles or surrogate objects - performed on flat outdoor test ranges. The influence of ground reflection and several means to reduce this effect are investigated and compared. Results are derived with theoretical formulas and simple models.

9:20 ***Satisfaction Indicators Taking into Account the Measurement and Computation Uncertainties for the Comparison of Data in Electromagnetics: Motivations and Scheduled Tasks of the French National Working Group CDIIS***

Genevieve Maze-Merceur and Bertrand Etchessahar (CEA, France); Jean-Michel Geffrin (Institut Fresnel & Aix Marseille Univ, CNRS, Centrale Marseille, France); Amélie Litman (Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France); Antoine Roueff (Fresnel Institute & Ecole Centrale de Marseille, France); Philippe Besnier (IETR, France)

A national study of criteria able to provide a satisfaction indicator about the comparison of data from electromagnetic measurement and computation, taking into account their associated uncertainties, has been organized in the framework of a French Working Group of the GdR Ondes, called CDIIS (Comparaison de Données entachées d'Incertitudes: Indicateurs de Satisfaction). This Working Group involves several industrial or academic research laboratories, including laboratories depending on governmental organisms. Four tasks have been defined: 1/ Identification of a set of satisfaction indicators. 2/ Identification of pertinent test cases in different application domains of elec-tromagnetics. 3/ Application of the above criteria on the test cases. 4/ Conclusions: which criterion is best adapted to a given electromagnetism problem. This paper deals with Task 1 and discusses the results of various indicators applied to a canonical RCS (Radar Cross Section) test case.

9:40 ***Ray Tracing for Range-Doppler Simulation of 77 GHz Automotive Scenarios***

Stefan Wald (Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Germany); Frank Weinmann (Fraunhofer FHR, Germany)

This paper presents two different ray tracing approaches for the generation of synthetic scattered field strength data in automotive scenarios. The aim is to provide data which is accurate in amplitude and phase and can be used in signal processing algorithms. As an example, range-Doppler maps are calculated here, showing the capability and limitations of both approaches. Also prospects for improvement of both methods are discussed.

10:00 ***Compensation of Ambiguities in Fast ISAR Measurements***

Roland Moch and Dirk Heberling (RWTH Aachen University, Germany)

Scattering mechanisms of radar targets are analysed using Radar Cross-Section (RCS) images. Those measurements are performed in an anechoic chamber to avoid external influences having an impact on the results. An unambiguous range covering the whole measurement chamber to avoid aliasing effects can be accomplished depending on the frequency step size. Taking into account a high bandwidth to enable a fine range resolution, this results in a large number of required frequency points. A reduction of the amount of frequency points based on the physical target size instead of the whole facility dimensions is suggested. Therefore, an unambiguous measurement is required but it has to be measured only once and serves as reference. This allows to measure the remaining view angles ambiguously and mitigate arising aliasing effects using the reference. Hence, the measurement time is reduced or a lower intermediate frequency bandwidth allows increasing the dynamic range of RCS measurements.

H_A02 MM SubMM THz: H_A02 Millimeter, Sub-millimeter and TeraHertz Antennas

TOP

High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Paweł R. Bajurko (Warsaw University of Technology, Poland), Mourad Ibrahim (Prince Sultan University & Modern Science and Arts University, Saudi Arabia)

8:40 ***A Dual-Band Dual-Polarised Stacked Patch Antenna for 28 GHz and 39 GHz 5G Millimetre-Wave Communication***

Manoj Stanley, Yi Huang, Ahmed Alieldin, Sumin Joseph, Chaoyun Song and Tianyuan Jia (University of Liverpool, United Kingdom (Great Britain))

Rapid developments in wireless communications demand an antenna that can operate at dual frequency bands in a compact size. In this work, a dual-band dual-polarised antenna is proposed for future 5G wireless communications that can operate at 28 GHz and 39 GHz 5G frequency bands. The proposed antenna is a stacked capacitive coupled patch antenna with bend parasitic elements having a dual-polarisation capability. The design principles and the antenna performance are discussed in detail. The antenna covers 25.75-30.25 GHz and 36.5-41.5 GHz and has a broad bandwidth in both the frequency bands. The proposed antenna element has a peak gain of 7.14 dBi in the lower band and 6.44 dBi in the higher band. The antenna element has a compact size of 3.8 mm × 3.8 mm × 1 mm making it suitable for implementation of antenna arrays in mobile devices.

9:00 ***Low-Cost, Circulary Polarized, and Wideband U-Slot Microstrip Patch Antenna with Parastic Elements for WiGig and WPAN Applications***

Mourad Ibrahim (Prince Sultan University & Modern Science and Arts University, Saudi Arabia)

In this paper, a wideband circularly polarized well-matched square microstrip patch antenna with a λ/4 feeding network suitable for fifth generation applications at 60 GHz (v-band) is developed. In order to increase the antenna bandwidth a U-slot with two parasitic elements at 60 GHz is designed and simulated. A single layer element with more than 7.2 dBi gain at the frequency of 60 GHz is achieved. The proposed antenna has a wide bandwidth extend approximately from 53.3 GHz to 60.8 GHz of more than 87 % efficiency and VSWR less than 2. The proposed antenna exhibits a circular polarization with Axial Ratio (AR) ≤ 3 dB in frequency band from 56 GHz to 57.2 GHz (1.2 GHz). The analysis and optimization processes throughout this paper are carried out using High Frequency Surface Structure (HFSS) simulator and verified with Computer Simulation Technology (CST) simulator. Good agreement between the two simulators is obtained.

9:20 ***Novel 60 GHz DRA Topology Adapted to the LTCC Process***

Ruben Guerrero (IMT Atlantique, France); Francois Gallée (Télécom Bretagne, France); Camilla Karnfelt (Lab-STICC UMR 6285 & IMT Atlantique, Institut Mines-Telecom, France)

This paper presents a novel topology for the conception of a 60 GHz cylindrical dielectric resonator antenna (DRA) in LTCC (Low Temperature Co-Fired Ceramic) technology, through the application of the Theory of Characteristic Modes. The design process deals with the strategical introduction of a pair of two triangular-shaped supports at each side of the resonator, in order to properly fix its structure to the ground plane. This technique, compatible with the LTCC process, allows to avoid the use of adhesives, soldering substances or other mechanical procedures which could disturb the antenna properties, thereby leading to an improvement of the electrical performance and to ease the fabrication procedure. Moreover, the LTCC technology delivers an additional degree of freedom for the design, since it allows to build non canonical resonator shapes and to increase easily its associated number of substrate layers. The developed antenna covers the 57-63 GHz spectrum, being enabled for future 5G applications at the 60 GHz band. The mentioned topology could be extrapolated for the design of antenna arrays.

9:40 ***Wideband In-Lens Polarizer for Future High-Speed Wireless Communications***

Marta Arias Campo (Delft University of Technology, The Netherlands & IMST GmbH, Germany); Darwin Blanco and Giorgio Carluccio (Delft University of Technology, The Netherlands); Simona Bruni and Oliver Litschke (IMST GmbH, Germany); Nuria LLombart (Delft University of Technology, The Netherlands)

The increasing demand for high-speed wireless links requires the development of new approaches for future communication networks. A larger RF bandwidth can be allocated by moving to higher carrier signal frequencies, starting from 100 GHz, allowing for higher data rate capacities. In this contribution, a broadband G-band leaky-wave fed lens antenna with an integrated dielectric grid polarizer is presented. The antenna is able to achieve multiple directive circularly-polarized beams. A quasi-analytical technique based on Spectral Green's Functions combined with a numerical Floquet mode solver is used to optimize the lens aperture efficiency and axial ratio, validating the results via full wave simulations. A design is proposed in low dielectric permittivity material, achieving full-wave simulated aperture efficiency higher than 80% and an axial ratio (AR) lower than 3dB over a 40% relative bandwidth. The feed matching is better than -10dB in the whole frequency band. A prototype has been fabricated, for which first measurement results show promising performance.

10:00 ***AoA Estimation Scheme for Fully-Connected Hybrid Architecture Antenna Arrays***

Maria Trigka, Christos Mavrokefalidis and Kostas Berberidis (University of Patras, Greece)

In the context of this research work we study the Angle-of-Arrival estimation problem in a fully-connected hybrid structure antenna array. The estimation problem is considered at the receiver side where the hybrid architecture exploits in a novel way all antenna elements of a uniform linear array. To this end, a preprocessing scheme proposed in [1] is properly extended so as to be applicable for a fully connected architecture. The new scheme enables recovery of the snapshots that would have been obtained if a conventional (non-hybrid) uniform linear antenna array was employed. The problem is formulated considering non-constant envelope sources. Simulation results are also presented that illustrate the performance of the proposed scheme, when compared to conventional MUSIC algorithm and its hybrid version.

W_A02 Arrays Ant Wireless: W_A02 Arrays Antenna for Wireless Networks

TOP

Wireless Networks and Defense and Security / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Paola Pirinoli (Politecnico di Torino, Italy), Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

8:40 ***A Correcting Coupling Solution to Extend the Scanning Range of Large Printed Phased Arrays by Means of Identical Microstrip Lines Connecting the Sources Two by Two***

Aurélien Ayissi Manga (Institut d'Electronique et de Télécommunications de Rennes & Thales Systèmes Aéroportés, France); Raphael Gillard and Renaud Loison (IETR & INSA, France); Christian Renard (Thales Systèmes Aéroportés, France); Isabelle LeRoy-Naneix (THALES AIRBORNE SYSTEMS, France)

This paper presents a solution to extend the scan range of a 1x50 patch array whose performances are limited by scan blindness, due to a strong surface wave coupling. The proposed solution is based on the introduction of an additional coupling mechanism (the "correcting coupling") within the structure. Its goal is to compensate the detrimental effect of the coupling wave, and it is implemented by means of additional microstrip lines connecting the array sources. The present framework relates to the context of applications requiring a large scan range (up to 60°) and where no inter-element spacing modification is possible, as a result of strong T/R modules integration constraints. This work is the continuation of a previous proof of concept conducted in the case of a 1x3 array. In contrast with previous studies, in which the connecting lines differ from each other, the goal of this paper is to assess the performances achievable in large arrays when all lines are identical.

9:00 ***Leaky-Wave Antenna Array on BCB at Submillimeter Frequency Bands***

Adham Mahmoud (Institut d'Électronique et de Télécommunications de Rennes, France); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Ronan Sauleau (University of Rennes 1, France)

This paper presents the design of a leaky wave antenna array (LWA) on a polymer substrate operating at submillimeter frequency bands. A straight front face constrained lens is used to excite the array. The lens is implemented in substrate integrated waveguide (SIW) technology and fed by a SIW horn. Benzocyclobutene (BCB) polymer is used as substrate to implement the antenna structure. A reflection coefficient lower than -15 dB and a gain more than 15 dBi over a 20% fractional bandwidth from 270 GHz to 330 GHz are achieved. The antenna efficiency is estimated to be 25%.

9:20 ***Design of L-band Linear Phased Array with Dual Polarized Dipole Antenna***

Muhammad Saeed Khan and Wafa Abdouni (ETIC, United Arab Emirates)

This paper presents a L-band linear phased array antenna with 9 dual-port dipoles for polarization diversity and printed baluns. The polarization of the antenna element (dual-port dipole) can be reconfigured from linear to circular by changing the input phases of each antenna. The design satisfies some targeted specification such as a gain of 13 dB and a steering coverage of 90◦ in the complete bandwidth of 1.1 GHz to 1.3 GHz. To validate the simulated results, the linear array is manufactured and measured results are compared with simulated ones. The antenna array performance in terms of active reflection, radiation pattern, Side lobe losses (SLL) levels and steering coverage has been analyzed.

9:40 ***CMOS Connected Array with Polarization Reusage for Passive THz Imaging Applications***

Sven van Berkel, Satoshi Malotaux, Bart van den Bogert, Marco Spirito, Daniele Cavallo, Andrea Neto and Nuria LLombart (Delft University of Technology, The Netherlands)

Uncooled passive imaging applications in the THz-regime require efficient and wideband operation to enable real-time imaging with sub-Kelvin temperature sensitivity. When deciding the sampling periodicity of the feeds in a focal plane array (FPA), an important trade-off is made between the efficiency and angular resolution. This contribution presents the simulated performance of a tightly sampled connected array, offering near diffraction limited resolution, while still operating efficiently, with an average efficiency of 45%, over a 1:3 relative bandwidth from 200 GHz to 600 GHz. This high efficiency is achieved after maximizing the directivity of the individual feeds by resorting to a connected array supporting a leaky wave in the presence of a dielectric lens. The connected array is shown to be up to 2 times more efficient in comparison with uniform aperture feeds. Furthermore, the near diffraction limited resolution is achieved by exploiting the dual polarized incoherent nature of a blackbody source. The dipoles of the array are tapered with a 45 degree angle such that the array becomes geometrically identical in both the horizontal and vertical polarization directions. Such antenna architecture allows for doubling the amount of pixels on the same chip area, and therefore resolution, without losing in efficiency. The proposed array contains 3 by 3 pixels that are horizontally polarized and 2 by 2 vertically polarized elements. The array is supported in a 22nm CMOS stratification and the radiometric imaging performance is evaluated in terms of the radiometric pattern where it is shown that a detector NEP in the order of pW/sqrtHz is required in order to facilitate uncooled, passive imaging applications.

10:00 ***A Frequency-Scanned Continuous Transverse Stub Array with Broad Angle Based on SIW***

Houtong Qiu, Jinxin Du and Yingjie Yu (Shanghai University, P.R. China); Biao Du (JLRAT, P.R. China); Xuexia Yang (Shanghai University, P.R. China); Steven Gao (University of Kent, United Kingdom (Great Britain)); Yang Wu (The 54th Research Institute of CETC, P.R. China)

A broadband continuous transverse stub (CTS) antenna array with wide steering range based on substrate integrated waveguide (SIW) is proposed in this paper. The broad steering angle is obtained by the novel coplanar waveguide (CPW) feedline loaded by slow-wave-structure. A reflector is located at one-fourth wavelength away from the antenna array to reduce the backward radiation. The proposed design has been simulated using the full-wave simulator of HFSS. The simulated results show that the -10dB bandwidth of the antenna array is 47.8 % (from 8.6 to 14 GHz). The main beam of the array can scan from -40° to 56° in E-plane with the operation frequency varying from 8.6 to 14 GHz. The gain in main radiation directions change within 9.8 ~ 12.3 dBi for all steering directions.

Tuesday, April 2 8:40 - 12:30

CS26 Micr Sensors Biomed Apps: CS26 Microwave Sensors for Biomedical Applications

Biomedical / Convened Session / Antennas

Room: Oral Sessions: A2- Ustka

Chairs: Robin Augustine (Uppsala University, Sweden), Paul M Meaney (Dartmouth College, USA)

8:40 ***Transmission-Based Dielectric Probes for Surgical Applications***

Paul M Meaney (Dartmouth College, USA); Tomas Rydholm (Chalmers University of Technology, Sweden); Helena Brisby (Sahlgrenska University Hospital, Sweden)

We have developed a new type of transmission-based dielectric probe that is idea for certain surgical applications - most notably spinal fusion surgery. It utilizes small-diameter open-ended coaxial cables, but exploits the fact that for the vertebrae surgery, the surgeon has access to both sides of the bone. While the space separation needs to be small (<2 cm), it is sufficiently large to get a signal across. The mathematics is dramatically simplified since it operates in the far field for which a number of simplifications can be employed. The penetration depth is effectively the full span between the two probes which is dramatically larger than that for open-ended coaxial reflection-based probes. Because it operates in the transmission mode, the effects from cable bending and such are minimal and subsequently lends itself to hand held operation which will be critical for a surgical setting.

9:00 ***Wideband and Compact Magneto-Electric Dipole Antenna for Electromagnetic Medical Imaging Systems***

Amin Darvazehban (University of Queensland, Australia); Sasan Ahdi Rezaeieh and Amin Abbosh (The University of Queensland, Australia)

A wide band low profile directional magneto-electric antenna is presented. The antenna consists of a half-wavelength bow-tie electric dipole and a one wavelength circular magnetic dipole, both printed on different sides of an FR-4 substrate. The electric dipole antenna is directly fed by a Subminiature Version A (SMA) connector, whereas the magnetic loop is excited using proximity coupling. Two parasitic elements are designed to improve the bandwidth and increase gain. The antenna has wide frequency bandwidth of 80% at 0.7 -1.65 GHz with compact size of 0.3 λ0× 0.2 λ0× 0.01 λ0 (where λ0 is wavelength at lowest operation frequency). The antenna achieves a maximum realized gain of 6 dB with peak front to back ratio (FBR) of 15 dB.

9:20 ***Simulation Study of a Haemorrhagic Stroke Detector and Its Performance***

Andreas Fhager, Stefan Candefjord and Mikael Persson (Chalmers University of Technology, Sweden)

Intracranial bleedings caused by stroke or head trauma is a serious condition that need immediate medical care and interventions. Pre-hospital detection and diagnosis would constitute a major breakthrough in streamlining the care and in reducing the time from incidence to start of treatment. In this paper we present a numerical simulation study to investigate the detection capability of a machine learning algorithm and its performance when diagnosing patients with intracranial bleedings from healthy subjects, for example hemorrhagic stroke patients from healthy persons. The specific goal is to study the training phase of the classifier and how parameters, such as number of antennas, number of training samples, noise, etc. affect the ability to detect bleedings with different volumes. The detection performance is evaluated in a cross-validation scheme.

9:40 ***A New Calculation Method for the Dielectric Constant of Low-Loss Materials***

Hassan Shwaykani, Ali El-Hajj and Joseph Costantine (American University of Beirut, Lebanon); Mohammed Al-Husseini (Beirut Research and Innovation Center, Lebanon)

In this paper, we present a novel technique to calculate the dielectric constant of low-loss materials with a thickness of more than half wavelength in the sample. The proposed method is valid for scenarios where the material under test (MUT) is inserted in a waveguide transmission line. The dielectric constant of the MUT is calculated by relying solely on the magnitude of the measured reflection coefficient (S11). This approach can be considered as complementary to the well-known NRW (Nicolson-Ross-Weir) method. The proposed technique provides a stable estimation of the dielectric constant of low loss materials over the studied frequency ranges. The method is also tested over a wide range of dielectric materials, where accurate estimation of their electric permittivity parameters are deduced. The proposed technique can also be extended to MUTs integrated in a transverse-electromagnetic (TEM) transmission line such as in a coaxial cable.

10:00 ***Imaging of Defect Responses on Cranial Vault Phantom Model Utilizing Curved Array Measurement***

Doojin Lee (University of Waterloo, Canada); George Shaker (University of Waterloo & Spark Tech Labs, Canada); Robin Augustine (Uppsala University, Sweden)

This paper presents the reconstructed curved images after craniotomy. The performance of the resistively tapered antenna is evaluated in terms of short-range sensing aspects. A series of amplitude scans along the curved array structure is proposed and measured. Three different conditions at the defect area are emulated and these images are reconstructed as a curved cranial shape.

10:20 Coffee Break

10:50 ***Preliminary Validations of Textile Wearable Microwave Sensor for Biomedical Applications***

Sandra Costanzo, Vincenzo Cioffi and Antonio Raffo (University of Calabria, Italy)

A patch antenna design on a textile substrate is presented in this work for the monitoring of blood glucose concentration. An improved dielectric model is introduced and adopted for blood, by specifically considering its dispersive behavior as well as the complex permittivity variations when changing the glucose concentration. Some preliminary numerical results are discussed to prove the potential application of the proposed wearable antenna in the non-invasive monitoring of diabetes disease.

11:10 ***Improved Sensor for Non-Invasive Assessment of Burn Injury Depth Using Microwave Reflectometry***

Syaiful Redzwan Mohd Shah and Jacob Velander (Uppsala University, Sweden); Mauricio D Perez (Uppsala University, Sweden & National Technological University, Argentina); Laya Joseph (FTE, Angstrom Laboratory, Lägerhyddsvägen 1 & Uppsala University, Sweden); Viktor Mattsson (Uppsala University, Sweden); Noor Badariah Asan (Uppsala University, Sweden & FKEKK, Universiti Teknikal Malaysia Melaka, Malaysia); Fredrik RM Huss (Uppsala University Hospital & Uppsala University, Sweden); Robin Augustine (Uppsala University, Sweden)

The European project "Senseburn" aims to develop a non-invasive diagnostic instrument for assessing the depth and propagation of human burns in the clinical scenario. This article introduces an improved flexible microwave split-ring resonator-based sensor, as a new development in this project. The excitation system and the fabrication process are the major improvements with respect to its precedent microwave sensor, both based in polydimethylsiloxane (PDMS) and copper. Both improvements are introduced together with the design of the sensor and of the experimental setup. Human tissue emulating phantoms are designed, fabricated, validated, and employed to emulate different burn depths and to validate the conceptual functionality of the proposed sensor. The Keysight dielectric probe 85070E is employed for the phantom validation. The analysis suggests that the sensor could estimate the burn depth. Future works will be carried out with ex vivo human tissues.

11:30 ***Development of 500 MHz - 20GHz Ultra-Wideband Multi-layered Heterogeneous Phantom of Different Human Soft Tissues for Various Microwaves Based Biomedical Applications***

Laya Joseph (FTE, Angstrom Laboratory, Lägerhyddsvägen 1 & Uppsala University, Sweden); Mauricio D Perez (Uppsala University, Sweden & National Technological University, Argentina); Robin Augustine (Uppsala University, Sweden)

In biomedical applications human body mimicking phantoms are becoming more useful for validation and testing of system prototypes. These artificial phantoms require stable and flexible tissue-mimicking materials with realistic dielectric properties in order to properly model human tissues. In this paper we propose an artificial tissue mimicking multi-layered phantom for soft tissues like skin, fat and muscle. We have chosen semi-solid phantom to emulate each tissue layer and fabricated a low cost, stable, nontoxic, long lasting, multi-layered heterogeneous phantom. Since the fabricated phantoms do not facilitate osmosis, they can be employed to construct heterogeneous phantoms or even anthropomorphic phantoms without causing any significant changes in geometry or electrical properties. The size and thickness of each layer is chosen based on the average thickness of human tissues. By altering the ingredient composition we can optimize the dielectric properties of the phantom. The dielectric properties of the fabricated set of phantoms are measured using an open-ended coaxial slim probe system by Keysight Technologies in the range of 500 MHz- 20 GHz ultra-wide band frequency.

11:50 ***Quasi- Open-Ended Coaxial Dielectric Probe Array for Skin Burn Characterization***

Paul M Meaney and Shireen Geimer (Dartmouth College, USA); Robin Augustine (Uppsala University, Sweden); Keith D. Paulsen (Dartmouth College, USA)

We have developed a planar probe for measuring dielectric properties. It exploits modern circuit board fabrication technologies that effectively construct a quasi-coaxial structure running perpendicular to the board. The feed line is a printed coplanar waveguide which comes in from the side on the top plane. The opening to the bottom behaves exactly like an open-ended coaxial probe. The initial results are comparable to the existing coaxial probes. The geometry of these probes allows them to be fabricated in an array utilizing standard, multi-layer circuit fabrication technology. These probe arrays may prove extremely useful in applications such as tumor margin detection for resected tissue, skin cancer screening and characterizing burns.

12:10 ***Wearable Monopole Antennas for Microwave Stroke Imaging***

Yatharth Thakkar (The University of Waikato, New Zealand); Xiaoyou Lin (University of Waikato, New Zealand); Yifan Chen (The University of Waikato, New Zealand); Fan Yang, Rui Wu and Xiaofeng Zhang (Shenzhen ET Medical Technology Co., Ltd., P.R. China)

Three compact wearable monopole antennas are proposed for stroke imaging applications. First, three different antenna geometries are developed based on a 1.6-mm-thick FR4 substrate. Then, a number of efforts are investigated and parametric studies are performed to reduce the antenna's sizes. The measured and simulated results show that the antennas achieve wideband and ultra-wideband (UWB) characteristics, partially covering the range of frequencies that can efficiently penetrate through the human head. These frequencies are from 0.6 GHz to 1.5 GHz both in free space and inside a matching medium. Simulations also show that the proposed antennas can achieve an omnidirectional radiation pattern and gains between 5 and 6 dBi, allowing for a good reception of signals being back-scattered from the human head. In addition, the omnidirectional radiation patterns provide flexibility to the antennas' orientation when placed on the interior surface of the helmet worn by patients.

Tuesday, April 2 10:50 - 12:30

CS9 Aper Array Radio Telesc: CS9 Antennas for Aperture Array Radio Telescopes

Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Eloy de Lera Acedo (University of Cambridge, United Kingdom (Great Britain)), David S Prinsloo (ASTRON & Netherlands Institute for Radio Astronomy, The Netherlands)

10:50 ***Near-field Calibration of SKA-Low Stations Using Unmanned Aerial Vehicles***

Loïc Van Hoorebeeck (Université Catholique de Louvain, Belgium); Jean Cavillot (Université Catholique de Louvain (UCL), Belgium); Ha Bui Van (Université Catholique de Louvain & ICTEAM, Belgium); Francois Glineur and Christophe Craeye (Université Catholique de Louvain, Belgium); Eloy de Lera Acedo (University of Cambridge, United Kingdom (Great Britain))

The low frequency part of the Square Kilometre Array (SKA-Low), currently in development, will need accurate calibration. A self-calibration is widely used in the radio astronomy literature and allows the calibration of several SKA pathfinders. However the increased sensitivity and the very large number of antennas of the SKA-Low reduce the hope for relying only on self-calibration. Research involving artificial sources carried by an unmanned aerial vehicle (UAV) has already led to successful far-field calibrations of radio telescopes. In this work, we show a characterization of the embedded element patterns (EEPs) carried out in the near field on a SKA-Low station composed of 256 log-periodic antennas. Two antennas mounted on a UAV act as calibration sources. Several flight strategies are studied with uncertainties on the UAV position and attitude. Using simulations, we show that near-field calibration enables to correctly model the array pattern. An advantage of near-field calibration is the lower required altitude which reduces the covering area of the UAV flight.

11:10 ***Efficient Performance Modelling of a Broadband Sparse-Regular Aperture Array Antenna Element***

Brandt Klopper and Dirk de Villiers (Stellenbosch University, South Africa)

A broadband dual-polarised antenna element is presented for a sparse-regular aperture array, for the Square Kilometre Array's Mid-frequency Aperture Array (MFAA). The element is required to operate not only under MFAA's specifications but also in the challenging sparse-regular array environment, where grating lobes can detrimentally affect the element's impedance and radiation responses at numerous scan angles and frequencies. The element's performance is modelled for a range of pertinent responses and figures-of-merit, including active reflection coefficient, intrinsic cross-polarisation ratio (IXR) and per-element receiving sensitivity. A global modelling method is also proposed to efficiently estimate the element's sensitivity performance across the full scan and frequency range. It is shown that the proposed design has several attractive qualities for MFAA, while also possessing sufficient degrees of design freedom to improve the element's overall performance beyond this first iteration.

11:30 ***Evaluating Receiver Noise Temperature of a Radio Telescope in the Presence of Mutual Coupling: Comparison of Current Methodologies***

Daniel Ung and Adrian Sutinjo (Curtin University, Australia); David B Davidson (Curtin University, Australia & Stellenbosch University, South Africa)

We present the computation of receiver noise temperature which includes the effects of mutual coupling of two different radio telescopes deployed in the Murchison Radio-astronomy Observatory, namely the Murchison Widefield Array and the prototype Engineering Development Array. We used three different formulations that only require information of measured noise parameters of the low noise amplifier as used in the radio telescope and simulated S-parameter of the array to perform the calculation. In addition, we show convergence in computed receiver noise temperature for various pointing angles and array configurations (uniform and pseudo-random) that indicate agreement with existing literature.

11:50 ***Characterization of the Murchison Widefield Array Dipole with a UAV-mounted Test Source***

Fabio Paonessa (National Research Council of Italy (CNR - IEIIT), Italy); Lorenzo Ciorba (Institute of Electronics, Computer and Telecommunication Engineering (IEIIT-CNR), Torino & Politecnico di Torino, Torino, Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Pietro Bolli (INAF - Osservatorio Astrofisico di Arcetri, Italy); Jader Monari and Federico Perini (INAF-IRA, Italy); Randall Wayth (International Centre for Radio Astronomy Research (ICRAR), Australia); Adrian Sutinjo (Curtin University, Australia); David B Davidson (Curtin University, Australia & Stellenbosch University, South Africa)

Aperture arrays such as the Australian Murchison Widefield Array (MWA) represent the modern approach to low frequency radio astronomy. The presence of mismatched front end amplifiers and mutual coupling between the array elements can produce distortions in the embedded-element patterns. Advanced techniques are therefore required to perform the in situ validation and instrumental calibration. Unmanned Aerial Vehicles (UAVs) technology provides suitable tools to accomplish these tasks. In preparation of possible UAV applications at the MWA site, some tests have been carried out in Italy on a subarray of MWA dipoles. This contribution presents the results of this measurement session with particular reference to the calibration of measurement equipment.

12:10 ***Performance Improvement of Self-Holography Based Aperture Array Station Calibration***

Cornelis Wilke (Stellenbosch University, South Africa); Stefan J. Wijnholds (ASTRON, The Netherlands); Jacki Gilmore (Stellenbosch University, South Africa)

The Mid-Frequency Aperture Array (MFAA) of the Square Kilometre Array will consist of around 250 stations (subarrays). Each of these stations will have between 103 and 104 receive paths. Calibration of the complex valued receive path gains is usually done based on the full array correlation matrix which, at this scale, can be extremely computationally expensive. To solve this problem a self-holography method is suggested in which the complex gains are calculated by correlating the receive paths with a reference signal obtained from the same station. Initial simulation results proved its feasibility but it was concluded that improvements can be made. This paper explores two methods to remove/ reduce this bias and to improve convergence. Simulations of these two methods are performed and the results are discussed.

F_M01 Test ranges: F_M01 Near-field, far-field, compact and RCS test ranges

Future Applications / Regular Session / Measurements

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Dirk Heberling (RWTH Aachen University, Germany), Peter Knott (Fraunhofer FHR, Germany)

10:50 ***A Modified Minimum-Coherence Sampling for Fast Spherical Near-Field Measurements***

Cosme Culotta-Lopez, Arya Bangun, Arash Behboodi, Rudolf Mathar and Dirk Heberling (RWTH Aachen University, Germany)

In this paper, a modified compressed sampling based on minimal mutual coherence for spherical near-field measurements is suggested. After defining the sampling points for minimal coherence, more sampling points along the positioner mechanical path are added following the principles of equiangular sampling. Since the number or length of positioner movements is not increased, the measurement speed stays the same while the acquired information is increased. Exploiting the sparsity of the Spherical Mode Coefficients (SMC), the SMC vector is reconstructed using compressed-sensing techniques. This scheme is applied to measured data. Using the SMC calculated from a measurement using equiangular sampling, the data at the given sampling points is calculated. From these new data, the SMC are reconstructed using basis pursuit. The reconstruction error is evaluated for schemes with a different number of sampling points. It is shown that the proposed sampling strategy allows for faster measurements with low error.

11:10 ***Baffle and SERAP Design for Compact Antenna Test Ranges***

Cecilia Cappellin and Per Nielsen (TICRA, Denmark); Damiano Trenta (European Space Agency, ESTEC, Italy); Luis Rolo (European Space Agency, The Netherlands)

A baffle and SERAP (Serration Radiation Protection) are designed to improve the quiet zone of the ESTEC Compact Payload Test Range (CPTR). The baffle has the purpose of preventing the feed to radiate in the quiet zone, while the SERAP prevents the feed to illuminate the main reflector serrations which create diffraction visible in the quiet zone. The baffle and SERAP are cylindrical structures covered by pyramidal absorbers, and their design is obtained with a general and computationally fast approach, which provides the radius of the cylinders and their location from the CPTR walls.

11:30 ***On Phaseless Spherical Near-Field Antenna Measurements***

Arya Bangun, Cosme Culotta-Lopez, Arash Behboodi, Rudolf Mathar and Dirk Heberling (RWTH Aachen University, Germany)

The application of phaseless measurement in spherical near-field antenna measurements is discussed. The amplitude is measured in spherical near field and is used to estimate the Spherical Mode Coefficients (SMC) of the antenna. Implementing phaseless measurement in a spherical near-field setting is challenging, since the spherical near-field data and its SMC depend highly on the structure of the spherical harmonics or Wigner D-functions, which can be seen as the Fourier basis on the sphere and rotation group. Similar to the phaseless Fourier measurement, considering only an amplitude measurement in this setting creates ambiguity in the reconstruction of the SMC. This paper shows the numerical investigation of several phaseless algorithms applied to spherical near-field antenna measurements.

11:50 ***Compact Antenna Test Range with New Shorter Focal Length for Heavy Duty Antenna Measurements***

Anders Jernberg (MVG Industries, Sweden); Moshe Pinkasy, Gennady Pinchuk, Tal Haze, Reuven Konevky, Lior Shmidov and Roni Braun (Orbit/FR, Israel); Andrea Giacomini and Lars Foged (Microwave Vision Italy, Italy); Grzegorz Baran (PIT-RADWAR S.A., Poland); Marcel Boumans (Antenna Measurement Experts GmbH)

In this paper a new shorter focal length design of a Compact Antenna Test Range (CATR) is presented. The new geometry allows the chamber size to be kept about 50% smaller than the geometry of the traditional CATR design. The range we present here has a cubic quiet zone (QZ) of 4.8 x 4.8 x 4.8 m, operating from 0.9 to 18 GHz within a chamber measuring 22 m x 14.5 m x 14.5 m.

The design is based on a novel, diagonally fed, short focal length reflector.

12:10 ***Comparison of Planar and Spherical Near-Field Antenna Measurements for a 60 GHz Dual-Polarized Probe and 60 GHz Offset Reflector Antenna***

Paula Irina Muntianu and Olav Breinbjerg (Technical University of Denmark, Denmark)

A comparison of 60 GHz planar and spherical near-field antenna measurements for two widely different antennas under test is presented to demonstrate how the non-ideal aspects of the measurement systems affect the far-field radiation patterns for mm-wave antennas. In general, a very good agreement is observed but clear differences are also noted.

C_P01 Prop for vehicular comm: C_P01 Propagation for vehicular communications

TOP

Cellular Communications / Regular Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Sana Salous (Durham University, United Kingdom (Great Britain)), Reiner S. Thomä (Ilmenau University of Technology, Germany)

10:50 ***Low Altitude Air-to-Ground Channel Characterization in LTE Network***

Xuesong Cai (Aalborg University, Denmark); Nanxin Wang, José Rodríguez-Piñeiro and Xuefeng Yin (Tongji University, P.R. China); Antonio Perez Yuste (Technical University of Madrid, Spain); Wei Fan, Guojin Zhang and Gert Pedersen (Aalborg University, Denmark); Li Tian (ZTE Corporation, P.R. China)

Low altitude unmanned aerial vehicle (UAV)-aided applications are promising in the future generation communication systems. In this paper, a recently conducted measurement campaign for characterizing the low-altitude air-to-ground (A2G) channel in a typical Long Term Evolution (LTE) network is introduced. Five horizontal flights at the heights of 15, 30, 50, 75, and 100m are applied, respectively. The realtime LTE downlink signal is recorded by using the Universal Software Radio Peripheral (USRP)-based channel sounder onboard the UAV. Channel impulse responses (CIRs) are extracted from the cell specific signals in the recorded downlink data. To shed lights on the physical propagation mechanisms, propagation graph simulation is exploited. Moreover, path loss at different heights are investigated and compared based on the empirical data. The simulated and empirical results provide valuable understanding of the low altitude A2G channels.

11:10 ***Investigation on Stationarity of V2V Channels in a Highway Scenario***

Daniel Czaniera and Martin Käske (Ilmenau University of Technology, Germany); Gerd Sommerkorn (Technische Universität Ilmenau, Germany); Christian Schneider and Reiner S. Thomä (Ilmenau University of Technology, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Mate Boban (Huawei German Research Center, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany)

This contribution investigates the stationarity of the vehicle to vehicle (V2V) channel in terms of distance and time. Due to high inherent mobility, the channel can not be assumed to follow the wide sense stationary (WSS) and uncorrelated scattering (US) assumption. Therefore, new evaluation methods have to be applied. We assess the stationarity for V2V highway scenarios using the generalized local scattering function (GLSF) and its collinearity based on measurements. We compare results for exemplary traffic situations and investigate the influence of the antenna placements on the stationarity of the channel. Our results yield a strong relation between the stationarity time and the change and rate-of-change of distance between transmitter and receiver.

11:30 ***Experimental and Analytical Characterization of Time-Variant V2V Channels in a Highway Scenario***

Gerd Sommerkorn (Technische Universität Ilmenau, Germany); Martin Käske, Daniel Czaniera and Christian Schneider (Ilmenau University of Technology, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany); Michael Walter (German Aerospace Center (DLR), Germany)

The time-variant characteristic of the vehicle to vehicle channel is discussed using measurements at 2.53 GHz from a highway scenario. For typical use cases, spectrograms in the time-delay as well as the Doppler domain are shown based on sequences of the generalized local scattering function. Delay-Doppler-bounds to be expected for single bounce reflections are determined by known movements of the transmitter and receiver using a channel representation in a prolate spheroidal coordinate system. Dominant moving scatterers are identified by visual inspection using proper meta data.

11:50 ***Experimental Characterization of V2I Radio Channel in a Suburban Environment***

Marwan Yusuf and Emmeric Tanghe (Ghent University, Belgium); Frédéric Challita (University of Lille & IEMN Lab, France); Pierre Laly, Davy P Gaillot and Martine Liénard (University of Lille, France); Bart Lannoo, Rafael Berkvens and Maarten Weyn (University of Antwerp - imec, Belgium); Luc Martens (Ghent University - imec, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper describes the results of the experimental vehicle-to-infrastructure radio channel sounding campaign at 1.35 GHz performed in a suburban environment in Lille, France. Based on the channel measurements acquired in vertical and horizontal polarizations, a multitaper estimator is used to estimate the local scattering function for sequential regions in time, from which Doppler and delay power profiles are deduced. We analyze second order statistics such as delay and Doppler spreads, as well as small-scale fading amplitude. A similar behavior between both polarizations is observed. In both cases, the statistical distributions of the RMS delay and Doppler spreads are best fitted to a lognormal model. The small-scale fading of the strongest path is found to be Rician distributed, while the later delay taps show occasional worse-than-Rayleigh behavior.

12:10 ***Measurement Based Determination of Parameters for In-stationary TDL Models with Reduced Number of Taps***

Nina Hassan, Martin Käske and Christian Schneider (Ilmenau University of Technology, Germany); Gerd Sommerkorn (Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

This paper proposes a new strategy of extracting parameters for tapped delay line channel models for vehicle to X channels from measurements. The proposed approach is based on an already existing method to derive parameters for a non-stationary tapped delay line model using first-order Markov chains. It will be shown that with a different method of choosing active-taps and the number of taps necessary to regenerate the delay spread of a channel can be significantly reduced. The feasibility of the method will be confirmed using channel sounding measurements.

C_A06 Multi Wide Band: C_A06 Multiband and wideband antennas

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Rossella Gaffoglio (LINKS Foundation, Italy), Anu Lehtovuori (Aalto University, Finland)

10:50 ***Ground Clearance in Smartphone Antennas***

Kimmo Rasilainen (Chalmers University of Technology, Sweden); Rasmus Luomaniemi, Anu Lehtovuori and Jari-Matti Hannula (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

This work investigates the effect of ground clearance on achievable smartphone antenna performance considering both industrial and scientific aspects. In addition to parametric studies, example antennas with small and large clearances are designed to visualise the design trade-offs in terms of size, bandwidth, and efficiency. Present antennas need a clearance of 5-6 mm to cover the low band at 698-960 MHz with an efficiency of -3 dB, whereas 3 mm is sufficient for comparable high-band performance.

11:10 ***Dual-Polarized Broadband Antenna for New Mobile Communication Base Stations***

Sergio Martin-Anton (University Carlos III of Madrid, Spain); Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain)

The present paper exhibits the design of a broadband antenna for new mobile base stations. The objective of this paper is the design of an antenna working in the extended 5G bandwidth in order to fulfill the future 5G requirement in the microwave region. The proposed topology is a pair of folded dipoles placed with an elliptical cylinder reflector. In this way, an element covering the frequency range of 1.45-2.69 GHz is obtained. In the end, two elements for achieving the required dual polarization are presented, in which the desired matching of -14 dB is obtained.

11:30 ***Air-Filled Substrate Integrate Waveguide Antenna Analyzed with Theory of Characteristic Modes***

Carlos Ramiro Peñafiel-Ojeda (Universitat Politècnica de València & Universidad Nacional de Chimborazo, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Eva Antonino-Daviu and Miguel Ferrando-Bataller (Universitat Politècnica de València, Spain)

An air-filled Substrate Integrated Waveguide (SIW) Antenna is presented in this paper. The main goal of this work is to design a low profile antenna (0.028 0 at the central frequency, 4.51 GHz) with a good bandwidth and unidirectional radiation pattern. To obtain this performance, the antenna is formed by four semi-closed SIW cavities without lateral sidewalls and is excited by means of a capacitive feed. A parametric study, carried out using an incident plane wave and the Theory of Characteristic Modes, has been used to study the behaviour of the semi-closed SIW cavity antenna. Simulated results show a good performance, covering the frequency range 3.37-5.65 GHz with a return loss above 10 dB.

11:50 ***A Compact Wideband Terrestial MIMO-Antenna Set for 4G, 5G, WLAN and V2X and Evaluation of Its LTE-Performance in an Urban Region***

Sertan Hastürkoglu (University of the Bundeswehr Munich, Germany); Mahmoud Almarashli (Universität der Bundeswehr München, Germany); Stefan Lindenmeier (Universität der Bundeswehr, Germany)

A MIMO antenna system is presented for integration into various mounting positions in automobiles, covering the entire frequency range of LTE, 5G, WLAN and V2X between 700 MHz and 6 GHz. The performance of the antenna is presented in detail and evaluated with simulation and measurements. Two of these antennas are measured in a set for MIMO on the roof of a car. It is shown that the antenna yields the required wideband and omnidirectional behavior, strong decoupling and efficiency. Results of a test drive of this MIMO system are presented as well, showing the throughput capacity in an urban environment and proving its high performance in comparison with a standard reference antenna set.

12:10 ***A Numerical Analysis of Compact/Wideband Antenna Performance for DTT Reception on Mobile Terminals***

Rossella Gaffoglio (LINKS Foundation, Italy); Marcello Zucchi and Giuseppe Vecchi (Politecnico di Torino, Italy); Bruno Sacco (RAI Research & Technology Innovation Center, Italy)

The attempts to design a broadband antenna operating at the lower ultrahigh-frequency (UHF) band for digital television reception in smartphone-type mobile terminals poses a great challenge for antenna engineers. Indeed, the limited dimensions of the mobile devices physically impose an upper bound to the achievable bandwidth of an embedded resonant antenna, introducing basic restrictions to the expected performance. This paper provides an analysis of an antenna prototype reported in literature in terms of realized gain, comparing its performance for different positions of the antenna element to that of an optimized standard PIFA.

CS45 Recent Adv Small Ant: CS45 Recent Advances in Small Antennas

TOP

Localization & Connected Objects / Convened Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain), Katarzyna Jagodzińska (Koszalin University of Technology, Poland)

10:50 ***Topology Sensitivity in Method of Moments***

Miloslav Capek and Lukas Jelinek (Czech Technical University in Prague, Czech Republic); Mats Gustafsson (Lund University, Sweden); Vit Losenicky (Czech Technical University in Prague, Czech Republic)

Topology sensitivity is derived for the method of moments. It shows how sensitive is a structure with respect to a given parameter if the smallest possible shape perturbation is performed. The method utilizes port modes and Woodbury identity. This makes it possible to evaluate the sensitivity without necessity to invert the impedance matrix. No modification of existent method of moments kernel is needed. Several examples are presented, discussing different shapes and antenna parameters. The method can be extended so it consecutively remove degrees of freedom, performing a shape optimization.

11:10 ***Design of Small Antennas with Optimized Embedded Loads Using the Characteristic Modes***

Hussein Jaafar (Universté de Rennes1 & IETR, France); Sylvain Collardey (University of Rennes 1, France); Ala Sharaiha (Université de Rennes 1 & IETR, France)

This paper presents the design of Electrically Small Antennas (ESAs) with embedded reactive loads. The reactive loads inside the antenna serves in controlling the currents that are supported by its structure in order to miniaturize and match the antenna in a wideband. The manipulation of the antenna currents is achieved by controlling the modal currents of the antenna or more specifically the Characteristic Modes (CMs). The CMs provides deep physical insights of the behavior of the antenna in terms of its resonance and the reactive interaction between the modes that are supported by its structure. Based on modal interpretation it would then be possible to optimally manipulate the antenna currents so that it could be matched in a wide bandwidth.

11:30 ***Small Circularly Polarized Button Antenna for 5 GHz Wearable Applications***

Xiaomu Hu, Sen Yan and Jiahao Zhang (KU Leuven, Belgium); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium)

A novel type of circularly polarized button antenna is proposed in this paper. The main radiator is constructed on a button shaped substrate, which is supported by a feeding probe on top of a textile layer. Both the impedance and the axial ratio bandwidth cover the 5.47-5.725 GHz U-NII world wide band. Measurements agree very well with simulations.

11:50 ***On the Efficiency of Miniaturized 360° Beam-Scanning Antenna***

Abel Abdul Zandamela (King Mongkut's University of Technology North Bangkok, Thailand & RWTH Aachen University, Germany); Korbinian Schraml (RWTH Aachen University, Germany); Vasan Jantarachote (King Mongkut's University of Technology North Bangkok, Thailand); Suramate Chalermwisutkul (King Mongkut's University of Technology North Bangkok & The Sirindhorn International Thai-German Graduate School of Engineering, Thailand); Dirk Heberling (RWTH Aachen University, Germany); Max James Ammann (Dublin Institute of Technology, Ireland); Adam Narbudowicz (Wroclaw University of Science and Technology, Poland & TU Dublin, Ireland)

The efficiency and beam-scanning performance of a compact beam reconfigurable antenna are presented. The proposed design achieves flexible switchless bidirectional radiation pattern of 360° in azimuth by using phase variations between its 3 ports. Antenna miniaturization is performed by dielectric loading; designs are presented for 4 different permittivity values, shifting the resonant frequency from 2.46GHz to 2.16GHz, 1.95GHz, and 1.8GHz. The simulated results show good linear beam-scanning despite a decrease in antenna efficiency.

12:10 ***Multifunctional Huygens Dipole Antennas***

Ming-Chun Tang (Chongqing University, P.R. China); Richard Ziolkowski (University of Technology Sydney, Australia & University of Arizona, USA)

Two electrically small, multifunctional Huygens dipole antennas that operate in the L-band are reviewed briefly. In both designs, two pairs of magnetic and electric near-field resonant parasitic (NFRP) elements are combined. Egyptian axe dipoles (EADs) generate the electric dipoles; capacitively loaded loops (CLLs) generate the magnetic dipoles. These NFPR elements are excited with coax-fed driven dipole elements. Both systems are low profile and radiate cardioid patterns pointed in the broadside direction. One Huygens antenna is a dual linearly polarized (dual-LP) system. The other one produces parallel, LP fields at two operating frequencies (dual-band LP).

R_A01 Rad adapt & Reconf Ant: R_A01 Radar adaptive and reconfigurable antennas

TOP

Radars / Regular Session / Antennas

Room: Oral Sessions: S4-D - Bytom

Chairs: Antonio Clemente (CEA-LETI Minatec, France), Stefania Monni (TNO Defence Security and Safety, The Netherlands)

10:50 ***Design of Polarization Reconfigurable Antenna Based on Rotatable Metasurface***

Jie Liu, Jian-ying Li, Rui Xu and Du Juan Wei (Northwestern Polytechnical University, P.R. China)

A planar slot antenna with the reconfigurable property of polarization is introduced in this paper. The polarization reconfiguration can be achieved by using a metasurface (MS) consisting of 16 elements with a rectangular configuration, which can be rotated to realize three polarizations states- left-hand circular polarization (LHCP), linear polarization (LP) and right-hand circular polarization (RHCP). To present the advantage of the proposed configuration, this antenna is fabricated and measured. The measurement results show that the performance of the MS antenna in impedance bandwidth, axial ration bandwidth (ARBW) and gain is better than that of original antenna.

11:10 ***Compact Design of a 24 GHz Extended Scan Range Rotman Lens Antenna***

Enrico Tolin (Politecnico di Torino, Italy & IMST GmbH, Germany); Oliver Litschke and Simona Bruni (IMST GmbH, Germany); Francesca Vipiana (Politecnico di Torino, Italy)

A compact realization of the method developed to increase the scan range of a 24 GHz phased array system based on Rotman lens as beamformer is presented and numerically validated. The two main operations composing the extended scan range method, named Complete Beam Shifting and Beam Mirroring are discussed and applied to the case of a Rotman lens initially designed for a maximum scan range of ±30°, resulting in a final maximum field of view ±60°. A reduced dimensions solution has been designed for a practical implementation of the novel method, including a suitable solution for realizing the Complete Beam Shifting and Beam Mirroring with a single phase shifter topology, introducing also a switchable version that fulfills the operational requirements.

11:30 ***Continuous Transverse Stub Antenna in PCB Technology***

Thomas Potelon (IETR - University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Terry Bateman and Jim Francey (Optiprint AG, Switzerland); Ronan Sauleau (University of Rennes 1, France)

We introduce here a new continuous transverse stub (CTS) antenna architecture compatible with standard, low-cost printed circuit board (PCB) technology for in-package systems. This enables a reduction of the cost, fabrication complexity and size of the antenna module. The antenna operates at E-band and its design, fabrication and experimental results are presented. To our knowledge, this is the first time that this technology is applied to CTS antennas. The measurement results are very promising: the radiation patterns are well-shaped, the gain variation over the 71-86GHz is lower than 3dB and the maximum measured gain is 17.2dBi.

11:50 ***Electronically Reconfigurable Unit-Cell and Transmitarray in Dual-Linear Polarization at Ka-Band***

Trung Kien Pham (University of Rennes 1 & IETR, France); Ronan Sauleau (University of Rennes 1, France); Antonio Clemente (CEA-LETI Minatec, France); Laurent Dussopt (CEA, LETI, Minatec, France)

This paper presents a multilayer reconfigurable unit-cell operating at Ka-band in dual-linear polarization. It consists of a passive narrow patch and active O-slotted rectangular patch loaded by two p-i-n. diodes. These patches are connected by a metallized via-hole, and the DC bias network is routed in one intermediate layer. This unit-cell exhibits a 1-bit phase resolution for an insertion loss below 1-dB at 29.5 GHz. The interleaving technique is applied to design a dual-polarized transmitarray with independent radiation characteristics between horizontal and vertical polarizations. The -1-dB transmission bandwidth of the unit-cell reaches 7.5 % around 29.5 GHz for both polarizations.

12:10 ***An Interleaved LTSA Array on a Waveguide Beamformer with Dual-Plane Monopulse***

Gokhan Gultepe and Doganay Dogan (Aselsan Inc., Turkey); Ozlem Aydin Civi (Middle East Technical University, Turkey)

A monopulse antenna array is designed by using a novel element combining wideband linearly tapered slot antennas (LTSA) with an interleaved, closely-spaced, travelling-wave slotted waveguide array (TWSWA) similar to [1-3]. To decrease the deteriorating coupling between sum and difference rows in previous studies for monopulse operation, adjacent rows of interleaved arrays are designed to have the same amplitude distribution but different propagation constants. So, interleaved arrays generate two simultaneous sum beams with distinct but close squint angles. Dual array elements are represented by 5-port networks. A 40-by-infinite array operating in 13% sidelobe bandwidth in C-band with 30-dB Taylor amplitude distribution is synthesized by the method proposed in [3]. The array is verified by full-wave simulations in HFSS.

H_A03 Array Ant: H_A03 Array Antennas, Antenna Systems and Architectures

TOP

High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Pavel Hazdra (Czech Technical University in Prague, Czech Republic), A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

10:50 ***Assessment on the Frequency Dependent Performance of Active Phased Arrays for 5G***

Antonius Johannes van den Biggelaar and Ulf Johannsen (Eindhoven University of Technology, The Netherlands); Marcel Geurts (NXP Semiconductors, The Netherlands); A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

To enable beamforming using active phased arrays, calibration of the array is a necessity. Typically, the array is assumed to be frequency independent within the frequency band of operation. However, an active phased array antenna will contain frequency dependent components, making the calibration essentially only valid for the center frequency of the frequency band of operation. In this paper, the results of an assessment on the frequency dependency of an active phased array antenna for the 28 GHz 5G band are presented. It is shown that for this active phased array antenna, the EIRP varies less than 1.2 dB within a 400 MHz channel, whereas the side lobe level typically increases several dB.

11:10 ***Wideband Sub-6 GHz Self-Grounded Bow-Tie Antenna with New Feeding Mechanism for 5G Communication Systems***

Mohammad Alibakhshikenari (Università degli Studi di Roma "Tor Vergata", Roma - ITALY, Italy); Sadegh Mansouri Moghaddam, Ashraf Uz Zaman and Jian Yang (Chalmers University of Technology, Sweden); Bal Virdee (London Metropolitan University, United Kingdom (Great Britain)); Ernesto Limiti (University of Rome Tor Vergata, Italy)

This paper presents a self-grounded directional Bow-Tie antenna with a novel feed structure for sub-6 GHz applications in 5G communication systems covering 3.35-4.4 GHz. The antenna consists of two petal shaped metal structures that are fed by a bend microstrip line with an out-of-phase excitation. The petals are anchored on a common ground-plane. The feed mechanism used to excite the petals is by EM coupling from a single open-circuited microstrip line implemented behind the ground-plane. The coupling of EM energy from the input microstrip line to the feed microstrip line is controlled via an I-shaped slot printed on the ground-plane. The proposed antenna offers good impedance matching across its operating frequency range with VSWR<2 and exhibits an average gain of 20 dBi for an 8×8 element antenna array.

11:30 ***Dual-Polarized MIMO Antenna Array Design Using Miniaturized Self-Complementary Structures for 5G Smartphone Applications***

Naser Ojaroudi Parchin (University of Bradford, United Kingdom, United Kingdom (Great Britain)); Yasir Ismael Abdulraheem Al-Yasir, James Noras and Raed A Abd-Alhameed (University of Bradford, United Kingdom (Great Britain))

In this study, a new eight-port dual-polarized multiple-input multiple output (MIMO) antenna array design for 5G smartphone applications is proposed. The design contains four pairs of compact dual-polarized self-complementary slot-patch antennas fed by a pair of independent coupled feeding structures. The radiation elements are designed to operate at 3.6 GHz and are located on the corners of the mobile-phone PCB with an overall dimension of 75×150 mm2. A Rogers 5880 dielectric with permittivity 2.2 and loss tangent 0.0009 is chosen as the PCB substrate. The antenna element is highly miniaturized and suitable for use in 4G/5G smartphones. The design not only provides the required radiation coverage but also generates dual-polarizations. The antenna offers good isolation, high-gain radiation patterns and sufficient efficiency.

11:50 ***A 26-31 GHz Beam Reconfigurable Dual-Polarization Antenna Array***

Kirill Klionovski (King Abdullah University of Science and Technology, Saudi Arabia); Mohammad S. Sharawi (Polytechnique Montreal, Canada); Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

The growing demand for higher data rates imposes special requirements for broadband, beam switching and dual-polarization mode for telecommunications antennas. In this paper, we present a design of 16-element planar patch antenna array with a Butler matrix feed network for the frequency range of 26-31.4 GHz. The antenna array operates with two linear orthogonal polarizations and provides ±42° beam switching. The Butler matrix is based on a novel combination of wideband planar couplers, crossovers and phase shifters. The design is fabricated on a low-cost multi-layer board. Experimental measurements of return loss, mutual coupling and radiation patterns confirm the wideband operational mode and wide-angle beam switching.

12:10 ***Multi-port Slot Array Antenna for Millimeter-wave Direction Finding and Beam-forming Applications***

Mohamed K. Emara and Daniel King (Carleton University, Canada); Hoang Nguyen and Samer Abielmona (Everest Networks Inc., Canada); Shulabh Gupta (Carleton University, Canada)

A simple multi-port antenna structure is proposed which can be used for direction finding (DF) and beam-forming applications in the receive and transmit modes, respectively. The proposed antenna offers unique functionalities in both receive and transmit modes. For DF applications in the receive mode, the beam-scanning laws of each antenna array is engineered to cover a given sector of space and the back-end of the system will feature a power sensing mechanism to monitor the power received at all ports. In the transmit mode, the proposed antenna can be used for beam-forming applications by engineering the individual port excitation and the antenna sub-arrays. The proposed antenna structure characteristics are demonstrated using full-wave simulations at 58-61~GHz based on circularly polarized slot arrays using substrate integrated waveguide (SIW) technology. Initial results show the antenna features high angle of arrival (AoA) resolution and a wide sector coverage, making it a good candidate for 5G wireless systems.

W_A04 MM Submm THz: W_A02 Millimeter, sub-millimeter and TeraHertz antennas

TOP

Wireless Networks and Defense and Security / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Carlos Del-Río (Universidad Publica de Navarra & Institute of Smart Cities, Spain), Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain)

10:50 ***Electronically Steerable Low-Sidelobe CRLH-metamaterial Leaky-Wave Antenna***

Senglee Foo (Huawei Technologies Canada, Canada)

This paper presents concept and design of an electronically beam steerable leaky-wave antenna (LWA) with extraordinary low sidelobes. The proposed LWA is constructed of liquid-crystal-loaded composite-right-left-handed (CRLH) metamaterial. Compared to a conventional leaky-wave array, this concept produces a high-gain beam with very low sidelobes. Radiation beam is electronically steerable over frequencies or at a fixed frequency point using electrostatic control of the liquid crystal.

11:10 ***Design of a Perforated Flat Luneburg Lens Antenna Array for Wideband Millimeter-Wave Applications***

Sara Manafi (University of Colorado Boulder, USA); Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Dejan Filipovic (University of Colorado at Boulder, USA)

Antenna array integrated with a flat Luneburg lens to form directive beam-steering system in a wideband millimeter-wave frequency range is investigated. The study and design of a perforated gradient index dielectric flat lens antenna for RF repeater application in V- and W- band (45 - 110 GHz) is presented. The flat Luneburg lens is designed to have a focal point away from its surface to enhance the radiation in a particular direction via a beam-switching system. Scanning capability of ±30° in both azimuth and elevation planes over the entire frequency range is demonstrated. Wider scan-beam angles at expense of higher scan losses are achievable by using the same type of lens configuration with different dimensions. Furthermore, these lenses are easy and cost-effective to prototype while maintaining the straightforward integration with antenna feed manifolds.

11:30 ***W-band Monopulse Antenna Array Manufactured by Diffusion Bonding***

Eduardo Garcia-Marin, Jose Luis Masa-Campos and Pablo Sanchez-Olivares (Universidad Autonoma de Madrid, Spain)

In this paper, a W-band monopulse array antenna has been designed and fabricated by diffusion bonding of thin copper sheets. The antenna consists of an array of 16 by 16 circularly polarized radiating cavities divided into four 8 by 8 sub-arrays, each fed by a corporate waveguide feeding network with a −20 dB Taylor distribution. An underlying beamforming network is implemented to provide monopulse capabilities in the two principal radiation planes. In the band from 90 to 98 GHz, the simulated axial ratio in broadside is under 2 dB, whereas the input matching is better than −15 dB in most of the band for the four input ports. The antenna has been fabricated and the experimental results show an impedance matching better than −10 dB in most of the band. Most notably, no frequency shift is observed in the results, corresponding to an improvement in the accuracy of the etching process compared to previous prototypes fabricated with diffusion bonding technology.

11:50 ***A Broadband Bow-Tie Cavity-Backed Slot for Traveling-Wave Arrays in the Millimeter-Wave Band***

Alberto Hernández-Escobar (Universidad de Málaga, Spain); Elena Abdo-Sánchez (University of Málaga & E. T. S. I. Telecomunicación, Spain); Carlos Camacho-Peñalosa (University of Málaga, Spain)

The use of bow-tie geometries to enhance the characteristics of a radiating element previously proposed by the authors is presented. The previous element consisted of a broadband cavity-backed slot in transmission configuration. The bow-tie shape of the cavity improves the bandwidth of the element and the bow-tie slot keeps constant the amount of power radiated. The structure is designed for the millimeterwave band. The enhancement of the element performance is shown through simulation results. A fractional bandwidth of more than 100% is achieved in the 70 GHz band, and the radiated power remains almost constant throughout 30 GHz of the bandwidth. These results show a great improvement over the original radiating element. The radiating structure has the ideal characteristics for building series-fed reconfigurable arrays for wide-band applications in the millimeter-wave band.

12:10 ***A Quasi-Optical System with 1 to 3 Relative Bandwidth for the ASTE Telescope***

Shahab Oddin Dabironezare and Giorgio Carluccio (Delft University of Technology, The Netherlands); Alejandro Pascual Laguna (Delft University of Technology & SRON, The Netherlands); Sebastian Hähnle (Netherlands Institute for Space Research, SRON, The Netherlands); Jochem Baselmans (SRON, The Netherlands); Nuria LLombart (Delft University of Technology, The Netherlands)

DESHIMA is a spectrometer for astronomical applications targeting sources at sub-mm wavelengths from 240GHz to 720GHz that will operate in the ASTE telescope in 2019. In this work, a quasi-optical system based on a hyper-hemispherical leaky lens antenna and a series of Dragonian reflectors is presented as the coupling chain for the EM radiation captured by the telescope into the detector. The design procedure is based on a field matching technique in reception starting from a plane wave illuminating an equivalent reflector model. By employing this methodology, the performance of the design is optimized over the whole 1:3 relative bandwidth. The achieved average illumination efficiency over the band is approximately 70%. The directivity patterns in the sky are also estimated. The side lobe, and cross-polarization levels, over the whole frequency band, are below -15dB, and -17dB, respectively. The measurement of the performance of the lens antenna coupled DESHIMA quasi-optical reflector system is planned for the upcoming months, and will be presented at the conference.

Tuesday, April 2 13:30 - 15:00

Poster_01: Poster_01

TOP

High Data-rate Transfer / Poster Session / Antennas

Room: Poster Sessions: P1 - Odra

Chairs: Piotr Kowalczyk (Gdansk University of Technology, Poland), Rafal Lech (Gdansk University of Technology, Poland)

Poster_01.1 ***A Model for Photocurrent Generation in Photoconductive Antennas***

Hector Lopez-Menchon (Universitat Politecnica de Catalunya (BarcelonaTECH), Spain); Sergio Revuelta Martínez (Universitat Politecnica de Catalunya, Spain); Maria C Santos (Universitat Politecnica Catalunya, Spain); Jordi Romeu and Juan M. Rius (Universitat Politècnica de Catalunya, Spain)

The laser-induced current carrier generation and transport under large biasing voltages in photoconductive materials located in electrode gap region of photoconductive antennas is a complex process involving many different phenomena that interact with each other in intricate ways. Given the large biasing voltages employed, a simple model that assumes that the carriers travel along the biasing field lines allows to retain the basic features of the photocarrier generation process. The model is presented in detail and results for a typical interdigitated electrode are shown to well agree with measures found in the literature.

Poster_01.2 ***Beam Steering of OAM Beams Using Time-switched Circular Patch Antenna Arrays***

Qilong Song and Hongtao Zhong (Chongqing University of Posts and Telecommunications, P.R. China); Alan Tennant (University of Sheffield, United Kingdom (Great Britain)); Yang Wang (Chongqing University of Posts and Telecommunications, P.R. China)

In this paper, time switched circular patch arrays are proposed to steer orbit angular moment (OAM) beams. OAM has been widely discussed as a new dimension to provide many channels for radio communications. One of the open issues is to steer and form the beam at lower cost. This paper introduces simple RF switch-controlled patch antennas to control the beams of OAM. Altering the signals loaded onto switches, a rotating phase profile can be added to the circular array and generate the OAM beam. Furthermore, the system can steer OAM beams by transform the beam-steering phase delay to time delays. Theoretical model of OAM beam steering based on the proposed practical 3.5 GHz arrays are produced along with numerical and full-wave simulations. Results suggest that the time-switched method is not only effective on theoretical isotropic elements but also realistic patch arrays, with advantages such as low cost and complexity.

Poster_01.3 ***Design of Wideband Dual-Circularly Polarized Endfire Antenna Array on Gap Waveguide***

Yuxuan Zhao, Enlin Wang and Dandan He (National Key Laboratory of Antennas and Microwave Technology, Xidian University, P.R. China); Tianling Zhang and Jian Yang (Chalmers University of Technology, Sweden)

A wideband dual-circularly polarized (CP) linear antenna array is presented in this paper. Firstly, a dual-CP endfire antenna based on septum polarizer is designed as the element for the array. Secondly, the feeding network is realized by ridge gap waveguide. Then a 1×8 linear antenna array is built up by the elements. The proposed array antenna achieves wide impedance bandwidth of 44.6% with the reflection coefficient below -10 dB, the isolation between ports greater than 15 dB, and a wide 3-dB axial ratio (AR) bandwidth of 46.2%.

Poster_01.4 ***A 28 GHz 8×1 Un-Equal Power Divider for Reducing Side-Lobe Level of MM-Wave Array Antenna for 5G Mobile Handset***

Jihoon Bang, Sungpeel Kim and Jaehoon Choi (Hanyang University, Korea)

A 28 GHz 8×1 un-equal power divider with optimized power division ratio to suppress the side-lobes of array antennas for mm-wave 5G mobile handsets is proposed. To obtain the required un-equal power division ratio, 14 SMD-type ceramic capacitors with different values are inserted in the proposed design. The normalized power division ratio of the proposed un-equal power divider at output ports is 0.23:0.38:0.66:1:0.99:0.72:0.39:0.26. As a result, the SLL is improved by about 7 dB, when the proposed un-equal power divider is applied to the mm-wave 5G array antenna in comparison to using a conventional equal power divider in the same array antenna.

Poster_01.5 ***Dual-Band Dual-Polarized Proximity Fed Patch Antenna for 28 GHz/39 GHz 5G Millimeter-Wave Communications***

Jaehoon Choi, Seongkyu Lee and Sunryul Kim (Hanyang University, Korea)

Dual-band dual-polarized proximity fed patch antenna for 28 GHz/39 GHz 5G millimeter-wave communications is proposed. A proximity fed square ring and a square patch were stacked and optimized for dual resonances at 28 GHz and 39 GHz. Two microstrip lines placed orthogonally to each other were used to generate the dual polarization. The simulated -10-dB S11 bandwidth was 400MHz (27.88-28.28 GHz) in 28 GHz band and 720 MHz (38.56-39.28 GHz) in 39 GHz band. The proposed antenna showed good radiation performances with low cross polarization level in both frequency bands. The sufficient isolation between the input ports 1 and 2 makes the consistent radiation performances with varying polarization mode in both 28 GHz and 39 GHz bands.

Poster_01.6 ***Extending the Bandwidth of UWB Monopole Antenna Using Genetic Algorithm with 5-6 GHz Notched Band***

Khelil Fertas (Ecole Nationale Polytechnique, Algeria); Farid Ghanem (Ecole de Technologie Superieure, Canada); Ali Mansoul (Division Telecom, Centre de Développement des Technologies Avancées- CDTA, Algeria); Mouloud Challal (University of Boumerdes, Algeria); Smail Tedjini (LCIS-valence, France); Rabia Aksas (Ecole Nationale Polytechnique, Algeria)

In this letter, a novel and compact ultra-wideband (UWB) antenna based on genetic algorithm optimization (GAO) with band-rejection using inverted Π shaped DGS filter is designed, fabricated and tested. This antenna formed by a main radiating patch element with an area divided into 2 mm x 2 mm shape where each one is allocated by presence conductor or absence of conductor property. The process is programmed in visual basic script and implemented in CST Microwave software as macro. The presented antenna, printed on Teflon substrate of dielectric constant 2.4 with loss tangent of 0.002, operates over a wide spectrum of frequency bands from 2.7 to 20 GHz. By using an inverted Π shaped slot etched in the ground plane, WLAN band elimination is achieved. Extremely interesting numerical results for the return loss, current distribution, radiation pattern and gain are illustrated and comment. The measured results are in good agreement with the simulated ones.

Poster_01.7 ***MIMO Performance Evaluation of Isotropic, Directional and Highly-Directional Antenna Systems for mm-Wave Communications***

Thomas Bressner and Amirashkan Farsaei (Eindhoven University of Technology, The Netherlands); Milad Fozooni (Ericsson Research, Sweden); Ulf Johannsen (Eindhoven University of Technology, The Netherlands); Martin Johansson (Ericsson Research, Sweden); A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

In this paper, we investigate how directional and highly-directional antenna systems using fixed beams can be beneficial in terms of aggregated channel and antenna gains, channel correlation and the massive multiple-input multipleoutput (MIMO) capacity in both line-of-sight (LOS) and non- LOS (NLOS) scenarios for single user MIMO (SU-MIMO). It is shown that narrower beams have stronger aggregated channel and antenna gain. However, narrow beamwidth triggers a higher channel correlation as fewer scatterers are seen. A possible solution to reduce the correlation among the beams is to properly decorrelate the beams in advance. To this end, we partition the area of interest and devote one specific partition to each beam to minimize the possible overlaps among the beams. Simulation results show that fixed beam SU-MIMO systems using such highly-directional beams can provide higher MIMO capacity in comparison to isotropic and directional antenna systems.

Poster_01.8 ***Modified SymmetricThree-stage Doherty Power Amplifier for 5G***

Maryam Sajedin (University of Aveiro, Portugal); Issa Elfergani and Jonathan Rodriguez (Instituto de Telecomunicações, Portugal); Raed A Abd-Alhameed (University of Bradford, United Kingdom (Great Britain))

This paper presents an advanced three-stage Doherty amplifier (DPA), using three 10W packaged GaNHEMT devices from CREE. The output matching networks consist of micro-strip line, lumped-parameter components and offset lines of the carrier and peaking cells that are used for proper load modulation. The transmission line in the input path of the carrier cell is inserted to adjust the delay among the carrier and peaking cells. The overall behavior of the threestage DPA with the target of high drain efficiency at 6 and 8dB output power back-off is compared with a two-stage Doherty power amplifier and single ended power amplifier, while operating at 3.6 GHz by using Agilent's Advanced Design System simulation. The designed three-stage power amplifier exhibits a power-added efficiency (PAE) of 40% at 6dB output power back-off, and 38% at 8dB output power back-off. The power amplifier is capable of delivering up to 43.2dBm of output power.

Poster_01.9 ***An Angularly Stable Broadband Cross-Polarization Conversion Metasurface***

Mudassir Murtaza (University of Engineering and Technology Taxila, Pakistan); Aamir Rashid (University of Engineering and Technology Taxila, Taxila, Pakistan); Tariq Ullah (University of Engineering and Technology Taxila, Pakistan); Farooq A. Tahir (National University of Sciences and Technology, Pakistan); Syed Zaidi

(UET, Pakistan)

A broadband cross-polarization conversion (CPC) metasurface is designed and analyzed for linearly polarized electromagnetic (EM) incidence. The unit cell of purposed design consists of rectangular split ring resonator with an X shaped pattern placed in the center. The unit cell is mounted on a grounded dielectric substrate to curb any kind of transmission of EM energy. An excellent cross-polarization conversion (CPC) is achieved from 17.46GHz to 29.85GHz with conversion efficiency higher than 98%, which is higher than other similar designs. Moreover, the structure is angularly stable up to 40^{o} of incidence angle. The design has 3dB fractional bandwidth of around 70% thanks to electric and magnetic resonances occurring at three distinct frequencies within the band of operation.

Poster_01.10 ***Flat Luneburg Lens at 0.24 THz for Antenna Beam Steering Applications***

Andre Sarker Andy (Queen Mary University of London, United Kingdom (Great Britain))

This paper presents an all dielectric flat Luneburg lens using transformation optics for THz beam steering. Using gradient-index dielectric materials it is possible to manipulate the direction of propagation of a THz wave in the medium. However, at THz frequencies, the dielectric losses become prominent and this suppresses the gain of a dielectric lens antenna. As a result, in this work the dielectric loss of the material for the THz lens is measured precisely and used in the modelled lens in CST Microwave Studio to predict its performance. Additionally, the possibility of beam steering using such a lens at THz frequencies is also discussed.

Poster_01.11 ***Integrated Filtering-Balun Planar Dipole Antenna***

Amira Eltokhy (University of Greenwich, United Kingdom (Great Britain)); Karim M. Nasr (University of Greenwich & University of Surrey, United Kingdom (Great Britain)); Yi Wang (University of Birmingham, United Kingdom (Great Britain))

In this paper, a planar filtering-balun dipole antenna design with a perpendicular ground is presented. This new filtenna design illustrates the use of a three-port coupled-resonator pair as a balun for a planar dipole antenna. It consists of two coupled open-loop resonators with a planar dipole acting as a third resonator. A horizontal reflector is added to improve directivity. A prototype is demonstrated at a center frequency of 2.34 GHz with a bandwidth of 320 MHz. Measured and simulated results are in good agreement showing a directive dipole antenna with a third order filtering functionality.

Poster_01.12 ***A mm-Wave Beam-Steerable Leaky-Wave Antenna with Ferroelectric Substructure***

Denys Nyzovets (Warsaw University of Technology & Institute of Radioelectronics, Poland); Yevhen Yashchyshyn (Warsaw University of Technology, Poland)

In this paper, a novel mm-wave beam-steerable antenna with ferroelectric substructure is presented. Ferroelectric substructure is placed under grounded substrate of antenna and coupled with it by three slots etched in internal metallic sheet. The radiation pattern control capability is demonstrated by varying the permittivity of the ferroelectric substructure. The proposed antenna is an excellent solution for a low-cost mm-wave beam-forming due to high radiation efficiency, high gain, low-profile, and low cost of manufacturing.

Poster_01.13 ***Design of an Electromechanically Tunable CPW Phase Shifter***

Anastasios Christodoulides and Alexandros Feresidis (University of Birmingham, United Kingdom (Great Britain))

This study presents the design and loss assessment of a tunable, phase shifting coplanar waveguide (CPW) line. The phase shifter consists of a CPW transmission line with a metallic loading strip suspended on top. The gap between them can be precisely altered with the use of piezoelectric actuators. By decreasing the CPW line width, the S21 losses decrease by almost 1 dB, and S11 stay well below -10 dB in all designs. The structures have been simulated with CST Microwave Studio, and the simulated results demonstrate a total phase shift of more than 180 degrees in all designs with good loss performance.

Poster_01.14 ***Multi-Band Balanced Printed Folded Arms Antennas for Heterogeneous Wireless Systems***

Issa Elfergani and Jonathan Rodriguez (Instituto de Telecomunicações, Portugal); Raed A Abd-Alhameed (University of Bradford, United Kingdom (Great Britain))

Two MIMO balanced antennas made of eight printed U-shaped folded arms are closely spaced, studied and tested. This MIMO antenna functions over multiple bands, including GPS, WiMAX, C-Band and WLAN systems. Such multi-band functions and size reduction are accomplished by printing folded 4-U shapes on the top and 4-U shapes on bottom of each antenna. The present MIMO layouts are fabricated over 1.6mm FR4 substrate and has come up with a compact size of 60 × 23 ×1.6 mm3.The two MIMO balanced antennas are placed over a ground plane dimension of 120mmx60mm2. For mutual coupling reduction, an I-shaped slot is produced on the ground plane that effectively lead to a mutual coupling of less than -10 dB at the four targeted bands. Other parameters such as gain, efficiency, radiation patterns and current surfaces are demonstrated and indicated favourable results. This makes the design a suitable candidate for future MIMO systems.

Poster_01.15 ***Environment-Embedded Radiation Patterns at Millimeter-Wave Frequencies***

Adrián Lahuerta-Lavieja (Katholieke Universiteit Leuven, Belgium); Martin Johansson (Ericsson Research, Sweden); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium); Ulf Gustavsson (Ericsson AB, Sweden)

The millimeter-wave (mm-wave) frequency spectrum is envisioned as a way to meet the ambitious and stringent goals of the fifth-generation of mobile communications (5G). Therefore, good characterization of environments of different nature is capital to gain insight in how such systems can become a reality. In this paper, the new concept of ``environment-embedded radiation pattern'' is introduced and worked out in a measurement campaign at 28 GHz. Scenarios with isolated large metallic objects and people were designed in order to capture scattering, specular reflection and diffraction phenomena, all incorporated in the embedded radiation patterns. The use of such environment-embedded radiation patterns is proposed for future mm-wave environments where the rich multipath assumption does not hold.

Poster_01.16 ***Millimeter-Wave Dielectric Resonator Antenna with Enhanced Gain Using Ridge-Gap Waveguide***

Mohamad Mantash (INRS-EMT, Canada); Zhenjiang Zhao and Huan Li (National Institute of Scientific Research (INRS), Canada); Tayeb A. Denidni (INRS-EMT, Canada)

This paper proposes a dielectric resonator antenna (DRA) with ridge-gap waveguide (RGW) feeding, that operates at 30.24 GHz. The RGW presents very low losses rendering high gain and high efficiency to the antenna. To demonstrate the validity of the proposed structure, simulations are performed and they show a bandwidth of 3.5 GHz, high realized gain of 9.76 dBi, total efficiency of 95.17% and side-lobe level of -13 dB at 30.24 GHz. From the results presented, the proposed dielectric resonator antenna can be used for different applications starting from commercial, up to important defense needs, especially for 5G wireless applications.

Poster_01.17 ***A Millimetre-Wave Two-Dimensional 64-Element Array for Large-Scale 5G Antenna Subsystems***

Ardavan Rahimian and Syeda Fizzah Jilani (Queen Mary University of London, United Kingdom (Great Britain)); Qammer H Abbasi (University of Glasgow, United Kingdom (Great Britain)); Akram Alomainy and Yasir Alfadhl (Queen Mary University of London, United Kingdom (Great Britain))

This paper presents the comprehensive design and evaluation of a novel large-scale millimetre-wave (mm-wave) two-dimensional (2-D) 64-element antenna array, for operation in the 28-GHz frequency band. The primary objective of this work is to study the feasibility of designing a high-performance array based on liquid-crystal polymer (LCP) substrate for the deployment in the fifth generation (5G) wireless communication networks and infrastructures. The planar 5G array has presented an impedance bandwidth of 400-GHz, with a peak gain of 23.2 dBi at 27.7-GHz. Moreover, the operation of the mm-wave antenna array has been analysed and validated through a set of high-resolution full-wave electromagnetic (EM) simulations, conducted based on the time-domain finite integration technique (FIT). The proposed 28-GHz 2-D antenna array is a high-performance subsystem in order to be potentially employed in the next-generation 5G communications.

Poster_01.18 ***A Wideband Circularly Polarized Grounded Coplanar Waveguide Fed Rectangular Frustum Dielectric Resonator Antenna***

Zheyi Yang and Zhengpeng Wang (Beihang University, P.R. China)

In this paper, a wideband circularly polarized grounded coplanar waveguide (GCPW) fed rectangular frustum shaped dielectric resonator antenna (DRA) is presented for millimeter wave applications. In the proposed DRA, right circular polarization is excited by grounded coplanar waveguide (GCPW) inductive slot feeding, which is tilted 45°angles with respect to the side of dielectric resonator. The optimized simulated result shows that 3dB axial ratio bandwidth of 13.15% (24.13 - 27.55Hz, 3.42GHz) and impedance bandwidth of 26.7% (22.07 - 29.01GHz, 6.94GHz) can be obtained, respectively.

Poster_01.19 ***Numerical Optimization of 2-D Luneburg Lens Antenna by Distorting the Permittivity Estimation to Improve the Beam Radiation***

Hsi-Tseng Chou (National Taiwan University, Taiwan); Chang Yi-Sheng and Hao-Ju Huang (Yuan Ze University, Taiwan); Zhi-Da Yan (National Taiwan University, Taiwan); Danai Torrungrueng (King Mongkut's University of Technology North Bangkok, Thailand)

This paper presents the design procedure of two-dimensional (2-D) Luneburg lens antennas based on numerical optimization of radiation and dielectric permittivity to improve the radiation patterns. A 2-D lens structure is considered for its extremely low profile realizable by dielectric substrates. The lens is discretized into several discrete concentric rings whose values of permittivity are optimized by two approaches of fitting them to the ideal curve in a minimum least square error (MLSE) fashion, and numerical simulation of radiation, respectively. The effects of this optimization are examined and validated by numerical simulation. Experimental results are also briefly discussed.

Poster_01.20 ***Mechanically Tunable Horn Filtenna for Mm-Waves***

Andreia Aparecida Castro Alves (Federal University of Itajubá, Brazil); Luis Da silva (INATEL, Brazil); Evandro Cesar Vilas Boas (Instituto Nacional de Telecomunicações, Brazil); Danilo Spadoti (Universidade Federal de Itajubá - UNIFEI, Brazil); Arismar Cerqueira S. Jr. (INATEL, Brazil)

This work reports the development of a mechanically tunable horn filtenna, operating in millimeter waves. The proposed waveguide-based filtenna represents the integration of a horn antenna and mechanically tunable filter based on dual-post resonators. The filter length is less than one guided wavelength and positioned into the available waveguide section between the horn aperture and feeder. Numerical and experimental reflection coefficient and simulated radiation pattern validate the proposed structure. Experimental results demonstrate a frequency tuning from 17.4 to 24.7 GHz.

Poster_01.21 ***Novel Approach for Designing Broadband Slot Antennas***

Hugo Filgueiras (National Institute of Telecommunications, Brazil); Tiago Brandão (Inatel, Brazil); James Kelly (Queen Mary University of London, United Kingdom (Great Britain)); Pei Xiao (University of Surrey, United Kingdom (Great Britain)); Arismar Cerqueira S. Jr. (INATEL, Brazil)

This paper presents a novel approach for designing broadband slot antennas. The proposed technique involves gradually incrementing the slot length along the propagation direction in order to provide a smoother impedance transition between the waveguide and air. Numerical and experimental results demonstrate up to 52.3% of bandwidth improvement by employing our approach in slotted-waveguide antenna arrays. The technique presents itself as a promising solution for 5G enhanced mobile broadband (eMBB) communications.

Poster_01.22 ***A Corner Expanded CPW-Fed Slot Antenna with Circular Polarization Characteristics***

Princy Paul (NIT, Suratkal, India); Krishnamoorthy Kandasamy (National Institute of Technology Karnataka, SURATKAL, India); Mohammad S. Sharawi (Polytechnique Montreal, Canada)

A planar, slot-based, simple and circularly polarized (CP) antenna is presented in this work. It consists of a square shaped slot that is fed via a coplanar waveguide (CPW) 50-ohm feed. The CP slot operates at a center frequency of 2.5GHz. Here, the corners are modified by adding small symmetric rectangular slot extensions to produce CP based waves. The plots obtained on simulation and measurement of the fabricated prototype display commendable similarity between each other. Very wide axial ratio bandwidth (ARBW) of 35% along with a maximum gain of 3.5dBi at 2.5GHz were accomplished.

Poster_01.23 ***Slotted Microstrip Leaky-wave Antennas for Backfire to Endfire Beam Steering***

Xiaolan Tang (Southern University of Science and Technology, P.R. China); Qingfeng Zhang (South University of Science and Technology of China, P.R. China); Yifan Chen (The University of Waikato, New Zealand)

Two periodic microstrip leaky-wave antennas providing beam scanning ability from backfire to endfire are presented in this paper. The proposed antennas consist of periodic patterned slots on the ground plane of the microstrip line. Both rectangular and sinusoidal slotted configurations are demonstrated, enabling the backward-to-forward radiation leakage as the operation frequency increases. Experimental results show that the peak gain of antennas exceed 12 dBi and the beam scanning range is 145° and 151°, respectively over a frequency range of 4.0-11.5 GHz and 4.7-7.7 GHz.

Poster_01.24 ***Conformal Transmitarray for Scan Loss Mitigation with Thinned Reconfiguration***

Timothy A. Hill (University of Surrey, United Kingdom (Great Britain)); James Kelly (Queen Mary University of London, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); Tim Brown (University of Surrey, United Kingdom (Great Britain))

A conformal transmitarray with thinned control is presented, operating at 28 GHz. Its side panels are rotated to align with the maximum steering angle, increasing the gain and reducing the scan loss. The transmitarray is fed by an 8-element linear phased array antenna. Beam focusing to +/- 53 degrees is demonstrated for two different directions, using combinations of crossed-slot unit cells. A unit cell placement rule is proposed to significantly reduce (i.e. thin) the required number of reconfigurable unit cells. A filling factor of 43% was achieved compared to a fully populated design. This reduces the cost and biasing complexity. By minimising scan loss, this antenna could improve the performance of 5G small-cell access points.

Poster_01.25 ***Path Loss Characterization for Intra-Vehicle Wearable Deployments at 60 GHz***

Vasilii Semkin (Université Catholique de Louvain, Belgium & Aalto University School of Electrical Engineering, Finland); Aleksei Ponomarenko-Timofeev (Tampere University of Technology, Finland); Aki Karttunen (Aalto University, Finland); Olga Galinina, Sergey Andreev and Yevgeni Koucheryavy (Tampere University of Technology, Finland)

In this work, we present the results of a wideband measurement campaign at 60 GHz conducted inside a Linkker electric city bus. Targeting prospective millimeter wave (mmWave) public transportation wearable scenarios, we mimic a typical deployment of mobile high-end consumer devices in a dense environment. Specifically, our intra-vehicle deployment includes one receiver and multiple transmitters corresponding to a mmWave access point and passengers' mobile devices. While the receiver is located in the front part of the bus, the transmitters repeat realistic locations of personal devices (i) at the seat level (e.g., a hand-held device) and (ii) at a height 70 cm above the seat (e.g., a wearable device: AR glasses or a head-mounted display). Further, we collect the measured data on the average received power and construct a logarithmic model for the distance-dependent path loss. The models developed in the course of this study can become of benefit for subsequent calculations of the link budget and interference footprint studies.

Poster_01.26 ***An Enhanced Pulse Position Modulation (PPM) for Both IR-UWB and DCC-UWB Communication***

Abdelmadjid Maali (Ecole Militaire Polytechnique, BEB, Alger, Algeria); Arezki Boukhelifa (EMP, Algeria); Mesloub Ammar, Sadoudi Said and Mustapha Benssalah (Ecole Militaire Polytechnique, Algeria)

In the present paper, an enhanced Pulse Position Modulation (PPM) technique is proposed for Ultra Wideband (UWB) communication systems based on Impulse Radio-UWB (IR-UWB) or Direct Chaotic Communication-UWB (DCC-UWB). The proposed technique is a non-coherent modulation based on using an adaptive threshold at the receiver. The basic idea consists on the use of hypothesis test, inspired from the Cell Averaging-Constant False Alarm Rate (CA-CFAR) algorithm used in Radar systems, to detect the received digital information. The simulation results show that the Bit Error Rate (BER) performance in Additive White Gaussian Noise (AWGN) channel is quite similar to the classical PPM and Chaos Based-PPM (CB-PPM) which use the maximum energy criteria to make a decision. However, in multipath environment such as indoor office LOS (Line Of Sight)/NLOS (Non Line Of Sight) and outdoor LOS/NLOS IEEE 802.15.4a channel models, the BER performance of the proposed CA-PPM outperforms those of the classical PPM and CB-PPM. The obtained results show that the proposed detection scheme opens promising perspectives and provides challenging performances for UWB communication systems.

Poster_01.27 ***Frequency Scaling from 19 to 39 GHz Using Alphasat Data from Prague***

Viktor Pek (Institute of Atmospheric Physics CAS, Czech Republic); Ondrej Fiser (Institute of Atmospheric Physics & Fac. of Electrical Engineering and Informatics/Uni of Pardubice, Czech Republic)

In this contribution we are constructing scatterplots of the 19 and 39 GHz attenuation measurement (pairs) of total atmospheric attenuation on satellite link. The results from the satellite Alphasat and two its beacon receivers at the Institute of Atmospheric Physics in Prague (Czech Republic) are used to investigate the frequency scaling. The usually used frequency scaling formulas are tested through our attenuation pairs 19-39 GHz (one minute values and peak values). The power law scaling method (n=1.4) seems to be most appropriate for our case. However, the ITU-R method could be also recommended as a general method.

Poster_01.28 ***Degrees of Freedom of UCA-Based Mode Division Multiplexing MIMO Systems***

Tao Hu, Yang Wang and Qilong Song (Chongqing University of Posts and Telecommunications, P.R. China); Jie Zhang (University of Sheffield, Dept. of Electronic and Electrical Engineering, United Kingdom (Great Britain))

The degrees of freedom (DOF) of UCA-based single-ring orbit angular momentum (OAM) communication system has been derived in this paper. It is found that the DOF of an mode division multiplexing (MDM) multiple-input multiple-output (MIMO) system depends on the sizes of both the transmit aperture and the receive aperture, the frequency of carrying wave, and the communication distance. For a given communication configuration, the simulation results show that the beam waist selection is crucial to maximize the number of DOF. Moreover, according to the expression of DOF, the OAM technique can perfectly combines with the millimeter wave communications due to low complexity in hardware design.

Poster_01.29 ***On Distance Factor in Rain Attenuation Predictions***

Pavel Valtr (Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic); Pavel Pechac (Czech Technical University in Prague, Czech Republic)

Comparison of rain attenuation prediction with measurements on commercial terrestrial microwave links at 25 GHz, 32 GHz and 38 GHz is presented. The comparison is done by means of cumulative probability distribution. Distance factor is included in the prediction to improve its accuracy. It is found that even with distance factor included, prediction systematically underestimates measured loss.

Poster_01.30 ***Characterization of 3D-Printed Choke Horn Antenna for 5G Backhaul Applications***

Carlos Biurrun-Quel (Universidad Publica de Navarra, Spain); Elsa Lacombe (University of Nice Sophia Antipolis & STMicroelectronics, France); Frédéric Gianesello (STMicroelectronics, France); Cyril Luxey (University Nice Sophia-Antipolis, France); Carlos Del-Río (Universidad Publica de Navarra & Institute of Smart Cities, Spain)

The 200 and 320 GHz frequency band constitutes an interesting window with approximately constant attenuation, which could potentially have applications in the area of ultrahigh- capacity wireless links. The user's demand of data for future 5G mobile systems will require backhaul systems to be able to provide several dozens of GHz in order to satisfy those demands. Furthermore, additive manufacturing techniques stand as an interesting way of reducing costs without sacrificing performance. In this work, a choke horn antenna, designed at a central frequency of 240 GHz and manufactured by 3D-printing technology is presented. This antenna is thought to serve as the feed of a compact parabolic reflector. The antenna has been measured by Near- and Far-Field techniques and these measurements show an adequate agreement with simulation results. Additionally, the measurement set-up included a novel dynamic time-domain, software-controlled gating that readjusts itself for every measured point.

Poster_01.31 ***Spatial Filtering in Planar near Field Antenna Measurement System and Comparison of Two Gain Calculation Approaches***

Goksenin Bozdag (TUBITAK BILGEM & Izmir Institute of Technology, Turkey); Okan Mert Yucedag, Yavuz Ozturk and Huseyin Yigit (TUBITAK BILGEM, Turkey); Huseyin Aniktar (Tubitak & Bilgem, Turkey)

In this study, a planar near field antenna measurement system with 4 m x 1.8 m rectilinear scanning area is introduced for evaluating far-field radiation characteristics and gain of directive antennas which are physically large and heavy. Its initial results are validated by using a standard horn antenna with medium gain at 13 GHz - 18 GHz frequency band. An optimum spatial filter is employed to decrease the error in radiation patterns. In the calculation of gain, two approaches based on pattern integration technique are investigated. Obtained radiation patterns for principal planes and the calculated gains are compared to the reference measurements and the ones provided in data sheet, respectively.

Poster_01.32 ***User Body Interaction of 5G Switchable Antenna System for Mobile Terminals at 28 GHz***

Rocio Rodriguez-Cano and Shuai Zhang (Aalborg University, Denmark); Kun Zhao (Sony Mobile Communication AB, Sweden & Aalborg University, Denmark); Gert Pedersen (Aalborg University, Denmark)

In this paper, a 12-element switchable antenna system for handsets is proposed at 28 GHz. The effect of the head and hand in the impedance matching and radiation pattern is assessed. The electromagnetic field (EMF) exposure in the body is analyzed. The evaluation method of exposure for the previous mobile generations is the specific absorption rate (SAR). Since the penetration depth of the EMFs is lower at the millimeter-wave (mm-wave) band, power density (PD) in free space is employed as evaluation metric instead. The maximum permissible transmitted power to satisfy the proposed limits is calculated, showing a severe discontinuity compared with the maximum power in 4G UE. The exposure of the switchable monopole is compared with a patch phased array, showing a faster decrease in the PD peak than the array at 1.3 cm from the terminal.

Poster_01.33 ***Integrated 60 GHz Array in SIW Technology***

Emilio Arnieri and Luigi Boccia (University of Calabria, Italy); G. Amendola (Universita della Calabria, Italy)

An Integrated array antenna in SIW technology is presented in this paper. A Shorted circular Patch Antenna (SAP) with a parasitic patch for gain maximization is used as single element. Simulated and measured results for the 4x4 array show a frequency stable radiation pattern over the entire operational bandwidth, with a maximum gain of 19.7dB. The proposed array is relatively compact, flexible and easy to build using standard PCB manufacturing process. For this reason, it is an excellent candidate for V-band planar integrated systems.

Poster_02: Poster_02

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Poster_02.1 ***Dynamic RCS Signature of a Ground Target Measured by a Dual-Mode Pulsed Radar***

Jianxiong Zhou and Rongqiang Zhu (National University of Defense Technology, P.R. China); ZhiGuang Shi (National University of Defence Technology, P.R. China); Qiang Fu (National University of Defense Technology, P.R. China)

The dynamic RCS data of a running truck are measured by a pulsed radar placed on a tower. The radar tracks the moving target and records data in either single-frequency or stepped-frequency mode. The calibrated dynamic RCS is estimated from the range-doppler images or the high resolution range profile sequences. The average level and the fluctuating characteristic of the dynamic RCS under different conditions are compared. The effects of the radar operation mode, the target aspect and the ground clutter are analyzed. The results provide a reference for radar system design in ground target detection and tracking applications.

Poster_02.2 ***Mutual Coupling Reduction of Aperture-Coupled Antenna Array Using UC-EBG Superstrate***

Prasetiyono Hari Mukti (Graz University of Technology, Austria & Institut Teknologi Sepuluh Nopember, Indonesia); Hossein Sarbandi Farahani and Helmut Paulitsch (Graz University of Technology, Austria); Wolfgang Boesch (Graz University of Technology & Institute of Microwave and Photonic Engineering, Austria)

The main challenge in development of antenna array is mutual coupling between two adjacent antenna elements. In this paper, a mutual coupling reduction of an antenna array structure using uniplanar compact electromagnetic bandgap (UC-EBG) superstrate is proposed. The antenna array developed in this paper is an aperture coupled antenna due to its ability to optimize antenna and feeding line separately. Due the UC-EBG superstrate structure consists of UC-EBG unit cells and superstrate layer, then the simple aperture coupled antenna array, superstrate-based antenna array and antenna array using UC-EBG superstrate are compared. The performance of these three antenna structures are numerically compared in terms of reflection coefficient, bandwidth, mutual coupling and radiation pattern. By using UC-EBG superstrate, we are not only achieve mutual coupling reduction, but also bandwidth enhancement.

Poster_02.3 ***Eleven Channel Retrodirective Metasurface Basedon the Combination of the Generalized Phase Lawand Impedance Modulation***

Mohammed Kalaagi, III (Universite Lille 1 & The French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks, France); Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France)

n this paper the design of a retrodirective meta- surface for multiple incident angles is proposed. The design methodology is based on the combination of the generalized phase law of reflection and the implementation of the phase impedance modulation for non reciprocal metasurfaces. An eleven channel retodirective metasurface has been designed and demonstrated. The monostatic radar cross section (RCS) has been calculated to determine the performance of the metasurface design at the desired angles of incidence.

Poster_02.4 ***Analysis of SIW-based Antennas with Arbitrary Slot Shapes***

Matthieu Bertrand and Guido Valerio (Sorbonne Université, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France)

In this paper, we propose a basis function sets hybridization for the Mode Matching/Moment Method analysis of SIW slot antennas. In particular, Rao-Wilton- Glisson (RWG) basis functions are used to describe the equivalent magnetic current distributions on arbitrarily shaped slots. Meanwhile, the code employs entire-domain sinusoidal functions for thin rectangular slots. Such an approach aims at providing both fast computing and accurate current description for a wide variety of slot geometries. These aspects are crucial for large SIW antenna optimization. A validation by comparison with a commercial software results is presented.

Poster_02.5 ***Measuring the Permittivity of Dielectric Materials by Using 140 GHz FMCW Radar Sensor***

Isam Alawneh (Ruhr Universty Bochum, Germany)

This work describes the use of frequency-modulated continuous-wave (FMCW) radar sensors for millimetre wave measurements to extract the dielectric constants of different types of dielectric materials. The FMCW radar measurements were done in the frequency range 122 GHz 169 GHz, and offer a fast and accurate measurement at much lower cost, especially at this high frequency range, when compared to a standard vector network analyzer. The extraction of the permittivity of dielectric materials is based on a monostatic radar measurement of the reflection coefficient by using free space setup. Therefore, a special measurement set up to operate at oblique incident angles was presented. The measurements setup will be described, as well as its implementation and calibration. To validate the reflection coefficient measurement results, an analytical model was implemented and presented. Finally, we show that our measurement setup system allows to characterize dielectric materials with high precision. The results from material characterization measurements in the millimetere-wave (mm-wave) was done for the following materials: Polytetrafluoroethylene (PTFE), polyvinylchloride (PVC), nylon, and gypsum.

Poster_02.6 ***Novel Integrated Antenna Array for Automotive Radars Operating at 77 GHz***

Hossam Helaly, Mohamed Serry and Ezzeldin Soliman (The American University in Cairo, Egypt)

This paper introduces a novel microstrip corporate array of wire-grid antennas. Coupled microstrip lines are used in constructing the corporate network and to feed the proposed array. The design is tuned to operate at 77 GHz to be suitable for long-range radar automobile applications. The antenna is designed in a layered medium formed from Rogers films. The proposed antenna is analyzed and partially optimized using Momentum of Advanced Designed System (ADS). The antenna radiates a fan beam, which is relatively narrow in one principal plane and relatively wide along the perpendicular plane. The obtained directivity, gain and radiation efficiency are 19.36 dBi, 17.3 dBi, and 62.6%, respectively.

Poster_02.7 ***On the Subarray Radiation Pattern in Phased Arrays with Interwoven Feeding Networks***

Sergei P. Skobelev (Radiophyzika, Russia)

Comparative analysis of the subarray radiation patterns and element use factor in the limited-scan phased arrays with interwoven and chessboard feeding networks is carried out. It is shown that though the attenuators in the interwoven networks can provide a wider sector of scanning at low level of the array factor grating lobes, their use results in a considerably greater number of the controlled elements necessary for providing specified gain in a specified sector of scan in comparison both with the case of the chessboard networks and with the case of the interwoven networks without the attenuators.

Poster_02.8 ***Two-Element Antenna-Active Phase Shifter Packaging at 77 GHz***

Mehdi Seyyedesfahlan (EPFL, Switzerland); Efe Ozturk (Silicon Radar, Germany); Mehmet Kaynak (IHP, Germany & Leibniz-Institut für innovative Mikroelektronik, Turkey); Ibrahim Tekin (Sabanci University, Turkey); Anja K. Skrivervik (EPFL, Switzerland)

This work presents a low cost and wire-bonded active phase shifter chip to RF circuitry on PCB board packaging for implementing a two-element phased array antenna at 77 GHz. The 1.5 mm × 1.1 mm chip is embedded in RO3003 PCB board and its GSG ports are wire-bonded to CPW lines that are expanded to feed the patch antenna on the PCB board. A low loss CPW to microstrip line transition is designed to exploit and transmit the signal from the GSG pads on the chip to the microstrip line on the PCB. The beam of the two-element array can be steered between ±20° by controlling the DC bias voltage of the active phase shifter chip.

Poster_02.9 ***A Novel Ultra-Wideband Switch-Type Active Frequency Selective Surface for Radome Applications***

Yulin Zhao, JiaHui Fu, Zhiming Liang, Zhiyi Zhang, Zhefei Wang, Kuang Zhang, Xumin Ding and Guohui Yang (Harbin Institute of Technology, P.R. China)

A switch-type polarization-insensitive active frequency selective surface (FSS) with ultra-wideband (UWB) characteristics is presented in this article. The proposed FSS consists of a periodic array of three metal layers, two dielectric layers and two air space. PIN diodes are arranged on the top and bottom metal layers which are related by two transmission lines. The transmission bandwidth of the active FSS with OFF-state diodes is 7.5-15 GHz with a fractional bandwidth of 67%, and the transmission coefficient of the FSS with ON-state diodes is lower than -14 dB from 2 to 18 GHz. Additionally, the active FSS is polarization-insensitive and angular stable for both TE and TM polarizations. The simulation results show the proposed active FSS is an effective candidate for radar radome applications.

Poster_02.10 ***Bandwidth Comparison of Topside Waveguide-to-Microstrip Transitions with Back-Short Waveguide and with Double-Layer Substrate in Millimeter-Wave Band***

Kunio Sakakibara, Tuan Thanh Nguyen and Nobuyoshi Kikuma (Nagoya Institute of Technology, Japan); Toshikazu Hori (University of Fukui, Japan)

Topside waveguide-to-microstrip transitions whose waveguide sits on the top of the substrate were developed in the millimeter-wave band. A substrate is attached on a back-short waveguide and the WR-10 waveguide is set on them. The microstrip line is inserted into the WR-10 waveguide, while the microstrip line is inserted into the back-short waveguide of the ordinary transition. A topside waveguide-to-microstrip transition with double layer substrate has been also developed. A coupling patch is located on the top surface with spacing of the upper substrate thickness from the microstrip signal line patterned between the upper and the lower substrates. The performance of the topside transitions with a back-short waveguide is compared with the transition with double layer substrate and the ordinary transition in this paper.

Poster_02.11 ***An Optimized Wideband Ridge Turnstile Junction with Compact Size***

Yidan Hu and Zhengpeng Wang (Beihang University, P.R. China)

This paper presents a broadband turnstile-based orthomode transducer junction achieving by ridge waveguides and a pyramid-shaped scattering element that is adopted as matching stub in the turnstile junction to provide good impedance matching with quad-ridge circular waveguide and single-ridge rectangular waveguides. The proposed structure covers the band from 1.7 to 5.83 GHz with an input reflection coefficient less than -20 dB. The simulated insertion loss is below 0.1 dB and the isolation is better than 55 dB. The dimensions of the junction are only 0.49λ × 0.49λ × 0.72λ at 1.7 GHz.

Poster_02.12 ***122 GHz Aperture-Coupled Mushroom EBG Antenna in LTCC Technology***

Akanksha Bhutani (Karlsruhe Institute of Technology, Germany); Benjamin Goettel (Wellenzahl Radar- und Sensortechnik GmbH & Co KG, Germany); Jonathan Mayer and Mario Pauli (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

This paper presents two variants of a mushroom electromagnetic bandgap (MEBG)-based antenna with an extremely thin antenna substrate, yet a high bandwidth-efficiency product. An MEBG unit cell (UC) exhibits two interesting electromagnetic (EM) properties, namely it shows a strong compression of resonance frequencies and it acts as a high impedance surface in specific frequency bands, thereby transforming surface waves into space waves. The EM properties of an MEBG UC are optimized around 122 GHz by simulating its dispersion diagram. Thereafter, a 4X4 and 6X6 matrix of the optimized MEBG UCs are used to form two multilayered antennas in low temperature co-fired ceramic (LTCC) technology. Both antennas are fed using aperture coupling and a stripline-to-grounded coplanar waveguide signal transition. Simulation and probe based measurement results of the antennas are presented between 110 and 150 GHz.

Poster_02.13 ***60GHz-Band Leaky-Wave Antenna for Remote Health Monitoring***

Muhammad S Rabbani, James Churm and Alexandros Feresidis (University of Birmingham, United Kingdom (Great Britain))

A high gain (22.6 dBi) wide-band (5 GHz) leaky-wave antenna (LWA) with beam scanning capabilities is presented for remote vital sign monitoring with Doppler radar technique at 60 GHz-Band (57-65 GHz) frequencies. A compact feeding structure is deployed to excite the antenna. The antenna input impedance matching is significantly improved by employing higher order resonant cavity height. A beam scanning range of about 12° is accomplished across the frequencies from 62-65 GHz. Since, a narrow frequency band is required for Doppler radar in vital sign monitoring, the antenna beam scanning is achieved by tuning the operating frequency across the mentioned band.

Poster_02.14 ***Design Method of Low RCS Antenna Array Based on Array Pattern Multiplication Theorem***

Yongtao Jia (National Laboratory of Science and Technology on Antenna and Microwaves, Xidian University, P.R. China); Ying Liu and Wen Bo Zhang (Xidian University, P.R. China)

In this paper, a design method of low RCS antenna array based on array pattern multiplication theorem is proposed. A circular polarization antenna is selected as the antenna unit. Based on the array pattern multiplication theorem, wide band RCS reduction is achieved by arranging the antenna units through sequential rotation. Meanwhile, the antenna array has good radiation performance

Poster_02.15 ***On the Design of Low Sidelobe Reflectarray with Enhanced Bandwidth at Ku-band***

Muhammad Wasif Niaz (Northwestern Polytechnical University, P.R. China); Ying Zeng Yin and Shufeng Zheng (Xidian University, P.R. China); Jingdong Chen (Northwestern Polytechnical University, P.R. China)

A low sidelobe reflectarray with enhanced bandwidth is designed in this paper. Low sidelobes are achieved by using a logarithmic spiral lattice for placement of unit cells on the reflectarray aperture. The unit cell is made up of a circular ring enclosing a rounded I-shaped dipole, which gives a smooth phase versus frequency response. The size of unit cells is much smaller than λo/2, which results in a large number of unit cells on the reflectarray aperture and an increased overall efficiency of the reflectarray. A 665-element reflectarray is designed and simulated, which gives a 1-dB gain bandwidth of 7.5% and -20-dB sidelobe level (SLL) bandwidth of 6.25% with a 60% aperture efficiency at 16 GHz.

Poster_02.16 ***Cavity-excited Ferroelectric Lens Antenna for Low-Sidelobe Beam Steering***

Huan Li (National Institute of Scientific Research (INRS), Canada); Mohamad Mantash (INRS-EMT, Canada); Zhenjiang Zhao (National Institute of Scientific Research (INRS), Canada); Tayeb A. Denidni (INRS-EMT, Canada)

Utilizing the technique of cavity excitation, this paper proposes a novel beam steering antenna with low sidelobe level. The whole beam steering antenna consists of two parts, i.e., a parallel plate waveguide based ferroelectric lens and a cavity-type feeding source. By independently tuning the DC bias voltage of each column of the ferroelectric lens, the beam of feeding source can be effectively collimated and steered in the far-field. By eliminating the spillover radiation at lens edge, low-sidelobe beam steering can be implemented. Full-wave simulated results show that the proposed antenna can achieve sidelobe levels of -34 dB at 0o steering angle and -25 dB at 30o steering angle. Without involving the complex feeding networks, the proposed lens antenna provides a promising alternative of complicated phased array antennas.

Poster_02.17 ***Numerical Investigation for Electromagnetic Interference Generated by Linear Motor of EMALS***

Meng Fan-Yi, Yu-Hang Liu, Wu Qun, JiaHui Fu, Guohui Yang, Kuang Zhang and Xumin Ding (Harbin Institute of Technology, P.R. China)

In this paper, the electromagnetic interference (EMI) generated by the electromagnetic aircraft launch system (EMALS) linear motor is numerically investigated. The full-scale EM model of the linear motor is build up and simulated by two steps in a private computer. In the first step, the magnetic field intensity distribution inside the linear motor and along the air gap is calculated and recorded as functions of time. In the second step, the magnetic field intensity data in time domain is divided into its frequency components, and used as source to excite the electromagnetic field outside the linear motor. It is found that, because of the nonlinearity caused by the movement of loads along the linear motor, there is not only strong static magnetic field component, but also strong second harmonic component of the magnetic field distributed around the linear motor. The space distribution of the static and second harmonic magnetic field components outside the linear motor is calculated. Results show that, even at the distance of as far as 5 m away from the linear motor, the two magnetic field components have the intensity of 263.5 uT, which is about 5 times of Earth magnetic field and have significant effect on electronic devices.

Poster_02.18 ***Wide-Angle Beam Scanning Phased Array Consisting of Cylindrical Dielectric Resonator Antennas***

Jianqiao Han, Meng Fan-Yi, Kuang Zhang, JiaHui Fu, Guohui Yang, Xumin Ding and Wu Qun (Harbin Institute of Technology, P.R. China)

In this paper, the design method for a wide-angle beam scanning phased array consisting of cylindrical dielectric resonator antenna (CDRA) elements with is proposed. The CDRA element is designed to work at HEM11δ mode, which produces wide-beam radiation patterns of 145° in the E-plane. Moreover, thanks to the high permittivity of the CDRA, the mutual coupling between the array elements is very small. Based on these critical features, the wide beam scanning range of the phased array can be achieved. A prototype sample of phased array consisting of 13 CDRA elements E-plane is designed and simulated. Results show that the radiation direction of the array can scan from -70° to +70° with a directivity fluctuation less than 1.5 dB, and the array supports the 3dB beam coverage from -82° to +82°. Over the whole scanning rang, the sidelobe level (SLL) is lower than -10 dB and the cross polarization is smaller than -38 dB.

Poster_02.19 ***Wrapped Resistively Loaded Antenna for Short Range Remote Sensing Applications***

Doojin Lee (University of Waterloo, Canada); George Shaker (University of Waterloo & Spark Tech Labs, Canada); William Melek (University of Waterloo, Canada)

This paper presents characteristics of a wrapped resistively load antenna for short range sensing applications. The wrapped antenna is fabricated on a flexible substrate of 0.13 mm thickness. The wrapped antenna with resistive tapering proposed and its performance metrics are evaluated. The wrapped antenna combined with drone arms targets remote sensing applications using multi-copters.

Poster_02.20 ***Comparison of FSS Topologies for Maximising the Bandwidth of Ultra-Thin Microwave Absorbers***

Gabriel G Machado (Queen's University Belfast, United Kingdom (Great Britain)); Robert Cahill (Queens University Belfast, United Kingdom (Great Britain)); Vincent Fusco (Queen's University Belfast, United Kingdom (Great Britain)); Gareth A Conway (Queen's University, Belfast, United Kingdom (Great Britain))

The maximum obtainable reflectivity bandwidth is compared for circuit analogue absorbers patterned with two different types of frequency selective surface (FSS). Metal backed resistively loaded FSS designs with thickness in the range of λ/18 to λ/14, were investigated to identify the crossover point below which the bandwidth of structures patterned with nested loops is narrower than a much simpler arrangement consisting of an array of patch elements. The results show that the deployment of a multi-resonant loop FSS, which are widely used to enhance the bandwidth of this class of microwave absorber, is undesirable below a threshold thickness where it is impossible to merge the individual absorption bands resulting from the nested loops. Numerical simulations are compared with radar backscatter measurements that were performed at normal incidence over the frequency range 7-14 GHz.

Poster_02.21 ***Design of a Sectoral Pattern Dual Shaped Reflector for Applications at Millimeter Waves***

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Matteo Albani (University of Siena, Italy)

In this paper, a design technique based on Geometrical Optics is proposed for the automatic optimization of a dual shaped reflector antenna radiating a sectoral beam in the azimuthal plane, for RADAR surveillance at millimeter waves.

Poster_02.22 ***Wideband SIW Cavity-Backed Slot Array Antenna with Flat Gain Characteristics for 79 GHz Automotive Radar***

Jiahao Xie, Qi Wu, Chen Yu, Haiming Wang and Wei Hong (Southeast University, P.R. China)

A wideband millimeter-wave SIW cavity-backed slot array antenna is proposed for 79 GHz automotive radar applications. The antenna element is composed of a slot fed substrate integrated waveguide (SIW) cavity which operates in TE210 mode, 4 pairs of symmetrical L-shaped radiating slots and 2 matching metallic blind holes. An 8-way SIW parallel power divider together with the antenna element is then utilized to feed a 2×4 array. By arranging the positions of metallic blind holes and metallic via holes, the electromagnetic energy leaking from bonding layer can be suppressed so that it causes no disturbance on radiation pattern while the SIW structure remains unchanged. The measured results show that the array antenna has flat gain characteristics in the frequency band of 75-82 GHz with gain variation less than 1 dB. Simulation and measurement results agree very well.

Poster_02.23 ***Design of a New Type Phase Shifting Array with Dual Radiating Modes***

Jianfeng Yu (East China Research Institute of Electronic Engineering, P.R. China)

This paper introduces a novel approach that integrates the radiating behaviors of reflectarrays and transmitarrays together. A dual-mode phase shifting array is applied for validation, which consists of split-diagonal-cross unit cells and a polarizing grid. The TE and TM polarized incident waves are separated into reflecting and transmitting modes due to the grid. Accordingly, one can easily switch the array between the forward and backward radiating modes individually. This simple solution can be potential as the increasing requirement of high integration in modern communications.

Poster_02.24 ***A High-gain Conical Conformal Antenna with Circularly Polarization and Axial Radiation in X-band***

Yuchen Gao, Wen Jiang and Tao Hong (Xidian University, P.R. China); Shuxi Gong (National Laboratory of Antennas and Microwave Technology, P.R. China)

A high-gain conical conformal antenna with right-hand circularly polarization (RHCP) and axial radiation is proposed in this paper. A double rhombus antenna with nine director strips is used to obtain the high-gain end-fire pattern. The four conformal elements evenly arranged on the cone are fed by the 1-to-4 Wilkinson feeding network with a 90° sequential phase difference to obtain an axial RHCP radiation. The simulation results show that the proposed antenna achieves an impendence bandwidth of 17.7% from 8.85 GHz to 10.57 GHz with the gain greater than 9.33 dBi, and the axial ratio of axial radiation is less than 1.85 dB in the operating band. The proposed antenna has a very low profile of 0.008λ0, which should be useful in the communication system of missile and aircraft applications in X-band.

Poster_02.25 ***Design and Measurements of A Tapered Slot Antenna Array with Suspended Stripline Probe Feed***

Jun Goto (Mitsubishi Electric Corporation, Japan)

This paper presents a novel cavity-backed tapered slot antenna array with suspended stripline probe feed. This antenna is composed of the tapered slot, the top/bottom layer of the suspended stripline, the dielectric substrate, and they can be easily assembled and disassembled by screwing all component for maintenance and upgrade purposes. Since the signal line on the substrate is close to the sidewall inside the suspended stripline, the reaction between them can make the cavity shallow. In this paper, the design and measurement results of the proposed antenna are presented. The bandwidth of the array is over 50% with active VSWR < 3, which is reasonably good performance considering its small size.

Poster_02.26 ***High Gain and Wideband Leaky Wave Holograms Using Gap Waveguide Surface Wave Launchers***

Mahsa Hamedani and Homayoon Oraizi (Iran University of Science and Technology, Iran); Davoud Zarifi (University of Kashan, Iran); Amrollah Amini (Iran University of Science and Technology, Iran)

In this paper a low loss, high gain and frequency scannable leaky wave holographic antenna is designed for operation in the frequency band 58 to 70 GHz. The antenna is realized based on the one-dimensional holography theory in the microwave frequency range. The antenna is composed of two basic sections: 1- A surface wave launcher for the generation of TM0 mode surface wave, and 2- A one-dimensional hologram for the transformation of surface wave to radiation mode at a desire direction. For the avoidance of losses and dielectric dispersion, unit cells made of metallic bed of pins are used for the realization of holographic surface. The hologram is designed to generate a beam at the angle of 30 degrees relative to the normal at the frequency of 62 GHz. The gap waveguide technology is used for the realization of surface wave launcher. The designed antenna is scannable from 26 to 45 degrees in elevation. In the pass-band the gain of antenna is better than 26:5 dB and its total efficiency is more than 90%.

Poster_02.27 ***An Accumulated Error Estimation Method for Non-uniform SAR Based on Sparse Observation***

Yan Zhang (School of Electronic and Information, Northwestern Polytechnical University, P.R. China); Baoping Wang (Northwestern Polytechnical University, P.R. China); Yang Fang (School of Electronic and Information, Northwestern Polytechnical University, P.R. China)

Non-uniform sampling error may cause defocusing in the reconstructed images. In the observation process, the observation positions are usually not known perfectly, and It is too expensive to estimate the position of each sample point. Here, from the error model analysis, we simplify the position error of each sampling point to an accumulated error in a synthetic aperture time. a Gaussian weighted projection coefficient sum by sparse observation matrix is used as the discrimination, and the error parameter is obtained by the golden ratio optimization algorithm with a chaotic sequences. Experimental results verify the effectiveness and efficiency of the proposed method

Poster_02.28 ***Clean Signal Reconstruction Approach for Purely Separating Hybrid Up- And Down-Chirp Orthogonal Waveforms***

Xinghua Liu, Zhenhai Xu, Luoshengbin Wang and Wei Dong (National University of Defense Technology, P.R. China); Shunping Xiao (National University of Denfence Technology, P.R. China)

Up- and down- chirp orthogonal waveforms are widely used in multiple-input multiple-output radar systems. However, the performance of these systems may be seriously limited due to the cross-correction energy leakage caused by the coupling between such chirp waveforms. In this letter, a clean signal reconstruction approach for purely separating the hybrid echoes of transmitted up- and down- chirp waveforms is proposed. This approach reconstructs the clean signal while eliminating the cross-correction energy leakage via a reconstruction-elimination-reconstruction framework. Since the majority of cross-correction energy leakages are eliminated, approximate pure separation can be achieved. Extensive and comparative simulation results validate the superiorities of this proposed approach.

Poster_02.29 ***A Bistatic Method for Radar Cross Section Measurements in the Fresnel Region***

Valentin Mihai (University Politehnica of Bucharest, Romania & The Institut d'Electronique et de Télécommunications de Rennes, France); Razvan D. Tamas (Constanta Maritime University, Romania); Ala Sharaiha (Université de Rennes 1 & IETR, France)

Fresnel region radar cross section analysis becomes a reliable solution when far-field conditions are difficult to fulfil. An approximated analytical expression for the radar cross section is derived based on the field integration on the target surface by assuming a constant current distribution on the transmitting antenna. The influences of environment and impedance mismatch are considered, provided that the measurements are performed in a multipath environment. Our method was validated by simulation and measurements on a rectangular, metallic plate.

Poster_03: Poster_03

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Cellular Communications / Poster Session / Antennas

Room: Poster Sessions: P3 - Warta

Chairs: Krzysztof Nyka (Gdansk University of Technology, Poland), Wlodzimierz Zieniutycz (Gdansk University of Technology, Poland)

Poster_03.1 ***A Technique of Antenna Integration with Energy Harvesting Windmill Generator for Autonomous Operation at Ocean Observation Platforms***

Pawel Kabacik, Arkadiusz Byndas and Mariusz Hofman (Wroclaw University of Science and Technology, Poland)

The paper is focused on results of our research work aiming at development of cylindrical antennas that can be integrated with a windmill and associated electrical generator. Owing to the cylindrical antenna form, the windmill must have vertical revolving axis. The dual-linearly polarized antenna is for operation with at least two microwave bands. The antenna shall provide minimum four identical sectorial beams in the azimuth plane. The electrical power energy production is expected from 50 to 300 Watts.

Poster_03.2 ***Cavity-backed Stacked Patch Array Antenna with Dual Polarization for mmWave 5G Base Stations***

In-June Hwang (Korea Advanced Institute of Science and Technology(KAIST), Korea); Hye-Won Jo (Korean Advanced Institute of Science and Technology, Korea); ByungKuon Ahn, Ju-Ik Oh and Jong-Won Yu (KAIST, Korea)

This paper proposed a dual polarized patch array antenna for millimeter-wave 5G base stations. The antenna operating at 28 GHz band is designed on 12-layer PCB lamination. A stacked patch topology was applied to secure the wide bandwidth of the antenna. In addition, in order to increase the gain of the patch antenna, a substrate-integrated cavity composed of via walls was applied. 8-element antenna array configuration was proposed for active antenna base station with vertical beam steering. Through simulated and measured results, it is determined that the proposed array antenna has good performance suitable for 5G base stations.

Poster_03.3 ***Study of Planar Wideband mm-Wave Bowtie Antennas over PCB Ground Plane***

Marko Sonkki (University of Oulu, Finland); Zeeshan Siddiqui (University of Oulu & Centre for Wireless Communications, Finland); Jiangcheng Chen and Marko E Leinonen (University of Oulu, Finland); Markus Berg (University of Oulu & Excellant LTd., Finland); Aarno Pärssinen (University of Oulu, Finland)

This paper presents bowtie antenna structure integrated on PCB, where on the other side of the substrate is the antenna itself, and on the other side is a conductive ground plane. Three different cases are studied with simulations and measurements in terms of impedance matching within 21 40 GHz bandwidth, depending on studied antenna structure. These three cases are linearly polarized single-ended bowtie, linearly polarized differentially fed bowtie, and differentially fed dual-polarized bowtie antenna. All antenna structures are on the ground plane of size 10 mm x 10 mm for easier comparison. Manufactured prototype antennas are measured and simulated with a 50 Ω coaxial feed. Simulated 3D radiation properties of the dual-polarized bowtie are presented at 28 GHz and 34 GHz, which both shows 95% simulated total efficiency.

Poster_03.4 ***Dual-beam Orthogonal Circular Polarized Antenna***

Shahin Salarian, Reza Mostafavi and Dariush Mirshekar (University of Essex, United Kingdom (Great Britain)); Gan Zheng (Loughborough University, United Kingdom (Great Britain))

A novel antenna structure has been proposed and investigated for mm-wave at 32GHz with 3.2GHz 10 dB bandwidth, with the potential to be scaled for 5G US band. The structure is composed of a monopole antenna and SIW wall. The proposed antenna structure was studied numerically, which reveals the directivity of 6.5 dBi in a bandwidth of 3.2GHz. In addition, the effects of different structural parameters have been investigated. The far field radiation pattern of the antenna reveals two orthogonal beams, which are circularly polarized, separately in the left and right direction.

Poster_03.5 ***An Ultra-Wideband Millimeter-wave Antenna Using a Novel Pentagon Filling Technique***

Hidayat Ullah (National University of Science and Technology, Pakistan); Farooq A. Tahir (National University of Sciences and Technology, Pakistan)

A 5G ultra-wideband monopole antenna working in millimeter-wave spectrum is being proposed here. Operating band of the antenna is 24.42-40.29 GHz exhibiting an enormous bandwidth of 15.87 GHz. The bandwidth coverage has been achieved by structuring the antenna through a unique method of pentagon filling. Low loss 0.254 mm thick Rogers substrate was used to attain radiation efficiency of more than 95% and a peak gain of 4.86 dBi. The antenna is compact in size with dimensions of 8×7 mm2. The proposed antenna is deemed suitable for future 5G and millimeter-wave communications due to its attractive characteristics.

Poster_03.6 ***Design of a Reference Dipole-Loop Antenna Array at 28 GHz***

Md Miah (Aalto University & School of Electrical Engineering, Finland); Mikko Heino (Aalto University, Finland); Clemens Icheln (Aalto University & School of Electrical Engineering, Finland); Katsuyuki Haneda (Aalto University, Finland)

This paper proposes an array antenna at 28 GHz that can be used to measure polarimetric omni-directional pathloss. The array consists of a printed microstrip dipole and loop with an integrated tapered balun structure. The design and experimental results of low profile microstrip dipole and loop antenna show wideband matching and radiation performance. Over 6 GHz of âˆ'10 dB impedance matching bandwidth has been achieved for the dipole, whereas the loop shows 0.2 GHz ranging from 27.9 to 28.1 GHz. A fairly good agreement between the simulated and measured radiation pattern validates our simulation method. The omni-directional behaviors of both dipole and loop makes it suitable as a reference antenna for over-the-air antenna testing at 28 GHz.

Poster_03.7 ***Printed Vertically-Polarized Quasi-Endfire Beam Steering Array with Full Ground Plane for 5G Mobile Applications***

Jin Zhang and Shuai Zhang (Aalborg University, Denmark); Yingsong Li (Harbin Engineering University, P.R. China); Gert Pedersen (Aalborg University, Denmark)

This paper proposes a quasi-endfire vertical polarized antenna array at 28.8 GHz for 5G mobile applications. The array element is composed of a dipole antenna with its two ends shorted by metallic via walls. The via walls have the same omni-directional radiation and 180 deg phase shift which generates a bi-directional radiation pattern. By adding another metallic via wall behind the array elements, it can act as a reflector, with the array radiating in only one direction. The antenna and array's performance are verified in the simulations. The structure presents good impedance matching and vertically-polarized quasi-endfire radiation patterns. Moreover, the array has low profile and needs no clearance on the ground plane.

Poster_03.8 ***Compact Fixed-Beam Leaky-Wave Antenna for 5G Millimeter-Wave Applications***

Kyriakos Neophytou (University of Cyprus, Cyprus); Matthias Steeg and Andreas Stöhr (University of Duisburg-Essen, Germany); Marco A. Antoniades (University of Cyprus, Cyprus)

A planar, compact, fixed-beam leaky-wave antenna operating at 26 GHz is proposed, that consists of a periodic arrangement of series-fed microstrip patches. The antenna consists of two oppositely-directed branches of the same periodic structure, and it is center fed through a 50 Ohm transmission line. The two branches of the antenna radiate their beam in opposite directions, and the combination of the two beams results in a broadside beam. To reduce the size of the antenna, a 180-degree bend is introduced at the center of each branch. This maintains the fixed-beam operation of the antenna for a wide bandwidth of 1.1 GHz, with a gain in excess of 14 dBi and a radiation efficiency of 65%, while reducing the overall size by a half.

Poster_03.9 ***Design of a 3D Printed Luneburg Lens Antenna for Multiple Beams Applications at Mm-Wave Frequencies***

Philippe Ratajczak (Orange Labs, France)

In this paper a 3D printed Luneburg lens is designed for multiple beams application at mm-wave frequencies. The control of the effective dielectric constant of each unit cell of the lens is done by adjusting the size of a nucleus located at the center of the cell. The effective dielectric constant calculus has been validated by experiments. The design of the Luneburg lens is presented with its simulated electromagnetic performance at 26 GHz. The lens antenna will be manufactured and tested.

Poster_03.10 ***Tunable Front-end Design with a Dual-band Antenna for Small Cellular Devices***

Hamid Amin and Jiangcheng Chen (University of Oulu, Finland); Markus Berg (University of Oulu & Excellant LTd., Finland); Aarno Pärssinen (University of Oulu, Finland)

Strict power and form factor requirements of miniaturized IoT wearable devices have introduced severe challenges in equipping them with multi-band cellular IoT connectivity. The antenna front-end renders the primary obstacle since supporting narrow and multi-band cellular connectivity requires a range with extensive coverage and high selectivity. This fact, in turn, would require a larger antenna and multiband filtering. Recently, high-Q tunable antennas have shown great potential in eliminating multiband filtering. However, their coverage and tuning range in small dimensions has proved to be inadequate to present a global coverage. This paper proposes a novel tunable antenna front-end architecture to address this problem. The proposed architecture benefits a dual-band, high-Q and tunable antenna in conjunction with tunable filters to cover a large variety of LTE-M bands in the resolution of 700 MHz to 2155 MHz including bands: 3, 4, 12, 13, 17 and 20. The design and implementation are discussed in detail, and related measurements are presented to prove the tuning capability.

Poster_03.11 ***A Low Profile Wideband Unidirectional Antenna for Wearable Device***

Jiangcheng Chen (University of Oulu, Finland); Markus Berg (University of Oulu & Excellant LTd., Finland); Aarno Pärssinen (University of Oulu, Finland)

In this paper, a wideband wristband antenna for wearable device, characterized by low profile and unidirectional radiation property, is proposed. First, the Theory of Characteristic Mode (TCM) is employed to expound the operation principle of the generation of unidirectional radiation. Then, an appropriate feeding structure is chosen to excite the desired modes. As a result, the corresponding modes are awaked and the unidirectional radiation is obtained. Moreover, the desired cellular operation bands (from 1710 MHz to 2155 MHz) are achieved. The total efficiency accompanied with flatness feature are at the levels of -1.5 dB and -6.5 dB in free space and with phantom respectively.

Poster_03.12 ***Compact Antenna System for a Smart Watch Using a Non-Resonant Element***

Aurora Andújar (Fractus, Spain); Yolanda Cobo (Universitat Ramon Llull, Spain); Ignasi Anglada (Fractus Antennas, Spain); Sungtek Kahng (University of Incheon, Korea); Jaume Anguera (Fractus Antennas & Universitat Ramon Llull, Spain)

A compact antenna system for a smart watch is presented. A non-resonant element (12 mm x 3 mm x 2.4 mm) is used to achieve operation for short-range wireless (2.4GHz-2.5GHz) and for mobile bands (824MHz-960MHz and 1710MHz-2170MHz). In both situations, the compact antenna system achieves its operation thanks to a proper design of a matching network. In this sense, there is no need to design a different antenna for each case, but only change the design of the matching network which is faster and easier. Measurements shows total efficiency for said two cases in the presence of a phantom hand. The main outputs of the present analysis are that height of the smart watch is relevant in order to minimize the power absorption due to the phantom hand. Moreover, for mobile operation, and in particular for the low bands at 824MHz-960MHz, a ground plane extension is a useful mechanism to achieve competitive efficiency values.

Poster_03.13 ***Dual Polarized 2X2 MIMO Antenna Based on Half Mode Substrate Integrated Waveguide***

Abubaker Elobied and Xuexia Yang (Shanghai University, P.R. China); Biao Du (JLRAT, P.R. China); Steven Gao (University of Kent, United Kingdom (Great Britain))

A novel compact 2×2 dual-polarized MIMO antenna based on half mode substrate integrated waveguide (HMSIW) is proposed. The four HMSIW antenna elements are printed orthogonally on the top of the substrate to achieve the dual polarization operation which results in a low mutual coupling. The separation distance between the antenna elements is only 0.032λo. The simulated impedance bandwidth is 2.4% from 4.77 to 4.89 GHz and the peak gain is 5.4 dBi on the broadside at the center frequency of 4.83 GHz. The mutual coupling level between the antenna elements is around -20 dB. The size of the MIMO antenna is 1.045λo×1.045λo× 0.025λo, which is a suitable candidate for upcoming 5G portable devices.

Poster_03.14 ***High Gain, Wideband Grid Array Antenna for 28GHz 5G Base Station***

Wai Yan Yong (University of Twente, The Netherlands); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

This paper proposes a high gain grid array antenna (GAA) with enhanced bandwidth for 5G base station application. The wideband GAA characteristics is achieved by loading the rhombus patch on the short radiating sides of the conventional GAA. By loading the rhombus on the short radiating sides of the conventional GAA, the additional capacitive reactance is introduced to cancel out the inductive reactance which lead to the enhancement on the bandwidth performance. The amplitude tapering is applied to reduce the side-lobes level of the grid array antenna. From the simulated results, it can be observed that the proposed GAA manage to support a –10 dB impedance bandwidth of 16.07% which is ranging from 27.5 GHz to 32 GHz with maximum achieved gain of 14.8 dBi. The overall dimension of the proposed wideband GAA is 25 × 25 × 0.787mm3 .

Poster_03.15 ***A Novel Magnetic-Free Broadband Circulator Based on Three Switched Delay Lines***

Dawei Tang (Southwest Jiaotong University XIPU Campus, P.R. China); Qianyin Xiang, Dengyao Tian and Quanyuan Feng (Southwest Jiaotong University, P.R. China)

A novel magnetic-free circulator is designed based on three switched delay lines with a total electrical length of 180-degree at the switching frequency. The transmission and reflection characteristics of the circulator were investigated, and the calculation and simulation results show that the proposed magnetic-free non-reciprocal structure can work in a broadband. A prototype circuit was fabricated. In the frequency range of 300kHz-100MHz, the measurement shows that the reflection loss and isolation are more than 15 dB and 20 dB, and the insertion loss is less that 4 dB, respectively.

Poster_03.16 ***Sinusoidally Modulated Reactance Surface Loaded Leaky Coaxial Cable***

Zeeshan Siddiqui (University of Oulu & Centre for Wireless Communications, Finland); Marko Sonkki, Marko Tuhkala and Sami Myllymaki (University of Oulu, Finland)

In this paper, the theory of sinusoidally modulated reactance surface (SMRS) is employed to enhance the radiation efficiency of leaky coaxial cable (LCX). The LCX's slots are loaded by a periodically etched dielectric stripe, partially converting the bounded monofilar mode into a radiating mode. The simulated results are discussed and it is shown that the coupling loss can be significantly decreased by SMRS loading, which increases the indoor coverage capability of the LCX.

Poster_03.17 ***Gain-Reconfigurable Hybrid Metal-Graphene Printed Yagi Antenna for Energy Harvesting Applications***

Antonio Alex-Amor (University of Malaga and Technical University of Madrid); Elena de la Fuente (Technical University of Madrid, Spain); Angel Palomares-Caballero (University of Malaga and University of Granada); Alfonso Muriel-Barrado (Technical University of Madrid, Spain); Juan Valenzuela-Valdés (Universidad de Granada, Spain); Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Pablo Padilla (University of Granada, Spain)

This paper presents a hybrid metal-graphene printed Yagi antenna with reconfigurable gain that operates in the 5.5-GHz band. The balun and the driven elements are made of copper, while the directors are made of graphene. The graphene acts as a tunable material in the design. By switching the conductivity of the graphene, it is achieved a similar effect to adding or subtracting directors in the antenna. Hence the gain of the printed Yagi can be easily controlled. This could be of special interest in RF energy harvesting in the design of reconfigurable harvesting elements.

Poster_03.18 ***Phased Array Configuration Study for 5G Mobile Terminals***

Igor Syrytsin, Shuai Zhang and Gert Pedersen (Aalborg University, Denmark)

In this work, the wideband phased antenna array element with a clearance of 1 mm and bandwidth of 11.1 GHz has been proposed for the 5G mobile terminals. The proposed element is combined into phased array systems with a total number of 8 elements in three different ways. The configuration with four sub- arrays of 2 elements each, two sub-arrays of 4 elements each, and a phased array of 8 elements have been considered. It has been found that even though more elements give higher gain, the four sub-arrays of 2 elements each yield better coverage performance.

Poster_03.19 ***A Balanced Feed Quad-Ridged Horn Antenna***

Zhihao Zhao and Zhengpeng Wang (Beihang University, P.R. China)

This paper presents an optimized balanced feed quad-ridged horn antenna. The two SMA probes are inserted into two symmetric ridges, and the inner conductors of the coaxial probes are connected on the horn's symmetric center. A balanced feeding network consists of a power divider and two analog or digital phase shifters is introduced. By adjusting the phase of the phase shifter, the phase offset caused by structural asymmetry can be calibrated. Symmetrical radiation pattern and low cross polarization is achieved from 2 to 6 GHz in full wave simulation. This antenna is used as the feed antenna of Compact Antenna Test Range (CATR) or satellite reflector antenna.

Poster_03.20 ***Studies of Q-TEM Operation Band Affected by Ridge Line in Printed-RGW***

Zhenjiang Zhao (National Institute of Scientific Research (INRS), Canada); Mohamad Mantash (INRS-EMT, Canada); Huan Li (National Institute of Scientific Research (INRS), Canada); Tayeb A. Denidni (INRS-EMT, Canada)

In Printed-RGW, the operation band of Q-TEM mode is usually less than the stop-band of mushroom EBG. In this paper, the reasons of narrower bandwidth are firstly analyzed with model analysis method. It is observed that ridge line width and vias under ridge line play significant impacts on the operation bandwidth. These can help to design a desired operation band by adjusting the ridge line parameters.

Poster_03.21 ***Heat Transfer Enhancement in Passively Cooled 5G Base Station Antennas Using Thick Ground Planes***

Yanki Aslan and Jan Puskely (Delft University of Technology, The Netherlands); Antoine Roederer (Technical University of Delft, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

The thermal and electromagnetic effects of varying the ground plane thickness and aperture size of the 5G integrated base station antennas are investigated. A double-sided PCB structure is designed with antennas and digital beamforming chips on the opposite sides. Fully-passive cooling is achieved by using fanless CPU coolers attached to the chips. The simulation results indicate that as compared to the standard counterparts, much better cooling performance can be achieved using relatively thick ground planes with extended aperture sizes, with no significant effect on the electromagnetic properties.

Poster_03.22 ***Effect of Slot Structure in Isolation of a Closely-spaced PIFA MIMO Antenna Design for Future 5G Applications***

Bazilah Baharom (Universiti Teknologi Mara, Malaysia); Mohd Tarmizi Ali Ali (Universiti Teknologi Mara, Malaysia); Robiatun Adayiah Awang (MARA University of Technology, Malaysia); Hajar Ja'afar (Universiti Teknologi MARA, Malaysia)

This paper presents a slotted structure at the ground plane and its effect on the isolation and gain of the proposed antenna. The two-element PIFA MIMO have been designed on full copper plate material with a thickness of Tc = 0.45mm. The proposed antenna with dimensions of 20mmx26mm² with a height of the top patch from the ground plane was 1mm. The antenna elements are placed in orthogonal position and spatial diversity pattern towards each other on a single ground plane with air as a substrate. The simulated and measured results of the proposed technique show the satisfactory performance, with gain from 6 dB to 9 dB and mutual coupling reduced to around -31 dB at the resonant frequency 15 GHz. This study is useful for future 5G wireless applications.

Poster_03.23 ***Numerical Transformation of Power Azimuth Spectrum into Normalized Doppler Spectrum***

Jan M. Kelner and Cezary Ziółkowski (Military University of Technology, Poland)

A power azimuth spectrum (PAS) and Doppler spectrum (DS) are one of the most popular channel characteristics. The former is used to describe a dispersion of a signal reception angle. The second one illustrates the received signal dispersion in a frequency domain. Usually, estimation methods based on measurements and modeling methods for these channel characteristics are definitely different. This is due to the fact that the PAS reflect a static situation related to one or several measurement points, while the DS corresponds to a dynamic situation obtained during a movement of objects (transmitter or receiver) at a specified route. Despite these differences, a close relationship exists between these characteristics because the Doppler frequency shift is associated with the angle of arrival. In this paper, this relationship and the numerical transformation of the PAS to DS are shown. The presented transformation allows for a quick estimation of the normalized DS shape based on the measured or modeled PAS. The proposed transformation is universal and allows determining the shapes of many DSs depending on the analyzed directions of the object movement based on one PAS only.

Poster_03.24 ***New Analytical PCE Coefficients for Uncertainty Quantification in Ray-Tracing Modelling***

Piotr Górniak (Poznań University of Technology, Poland)

Ray-tracing simulations of stochastic electromagnetic fields are considered in the paper. The author uses polynomial chaos expansion (PCE) coefficients for uncertainty quantification. The author introduces the new effective method, in terms of accuracy and calculation speed, for analytical derivation of PCE coefficients in ray-tracing modelling. The analytical PCE coefficients can be recalculated very fast after a change of probability densities of random variables of a simulation. The new method is compared with general polynomial chaos (gPC) approach and collocation rules for an exemplary indoor scenario

Poster_03.25 ***Characterization of mmWave Radomes for Base Stations and Automotive Radars***

Jan Järveläinen (Premix Oy, Finland); Aki Karttunen (Aalto University, Finland); Jouko Aurinsalo (VTT Technical Research Centre of Finland, Finland); Ismo Huhtinen (VTT, Finland); Arto Hujanen (VTT Technical Research Centre of Finland, Finland)

In this paper, we have characterized dielectric properties of low-loss radome materials with three different measurement methods, at microwave and mmWave frequencies. The techniques include an over-the-air (OTA) far-field measurement at 55-95 GHz, a Fabry-Perot open resonator (10-60 GHz), and a split-post dielectric resonator whose empty resonance frequency is 2.45 GHz. Both resonator methods give very similar values for the dielectric constant and loss tangent, but the OTA measurement overestimates the dielectric constant by 8% and has larger variation between loss tangent values of different materials. Finally, it is evaluated how uncertainty in dielectric properties affect the radome performance.

Poster_03.26 ***Characteristics Evaluation and Path Loss Measurement of Vehicle Glass Mounted Antenna for 28-GHz Band***

Toshiki Sayama, Osamu Kagaya, Hideaki Shoji and Shoichi Takeuchi (AGC Inc., Japan); Kiyoshi Nobuoka (AGC Inc, Japan); Minoru Inomata and Tetsuro Imai (NTT DOCOMO, INC., Japan)

Due to high radio waves attenuation, directional antenna is widely studied in the 28GHz band which is considered to be a promising candidate band in 5G. On the other hand, since vehicle antenna is generally demanded to be omni-directional pattern, it is considered to realize omni-directional pattern by utilizing several directional antennas witch are mounted distributedly. In that case, glass windows facing all directions of the vehicle are desirable locations for antenna mounting. However, investigation of vehicle glass mounted antenna in the high frequency band such as 28GHz is not sufficient. Therefore, we obtained fundamental antenna characteristics from experiments in which 28GHz band antennas were mounted on front, rear, and both side glass windows. As a result, it was disclosed that the influence on the antenna characteristics varied depending on each window glass. Also, we confirmed the effectiveness of the vehicle glass mounted antenna by the path loss characteristics evaluation.

Poster_03.27 ***Over-the-Air Testing of Active Antenna System Base Stations in Compact Antenna Test Range***

Luca M. Tancioni (ORBIT/FR - Europe GmbH, Germany); Anders Jernberg (MVG Industries, Sweden); Per Noren (Microwave Vision Group, Sweden); Andrea Giacomini, Alessandro Scannavini and Lars Foged (Microwave Vision Italy, Italy); Roni Braun (Orbit/FR, USA); Marcel Boumans (ORBIT/FR Europe GmbH, Germany); Fredrik Hirn, Brett Horrocks and Claus Schröter (Ericsson AB, Sweden)

The definition of suitable test methods for Over the Air (OTA) measurements of non-connectorized devices is an ongoing process in several standardization committees. Among the different possibilities, the Compact Antenna Test Range (CATR) is a well-established technology that can be adapted to OTA measurement application with relatively low development efforts and therefore short deployment time. The main advantages of the use of a CATR for OTA testing is the direct measurement of Far-Field parameters, and the very wide frequency bandwith, allowing sub6GHz and mm-Wave testing. In this paper, we will summarize the performance and the testing capabilities of a short focal-length, corner-fed CATR design, providing a 1.5 m x 1.5 m cylindrical Quiet Zone, operating from 1.7 GHz to 40 GHz and upgradeable to 110 GHz, allowing OTA measurements of Active Antenna System (AAS) Base Stations (BS), installed at Ericsson premises in Sweden.

Poster_03.28 ***Mobile Phased Antenna Array @ 6 GHz with Digitally Tunable Capacitor Phase Shifters***

Carla Di Paola, Samantha Caporal del Barrio and Shuai Zhang (Aalborg University, Denmark); Art Morris (Wispry, USA); Gert Pedersen (Aalborg University, Denmark)

This paper evaluates the performance of the digitally tunable capacitor phase shifter, mounted on a phased antenna array, in the frequency range from 5 to 6 GHz. It is based on the WS1042, a single-chip, fully-integrated tunable RF capacitor featuring four high resolution, tunable MEMS capacitors under control of a MIPI RFFE serial interface. The design of the phased antenna array consists of four quarter wavelength dipoles printed on the short edge of an FR4 substrate. Simulations including 70° and 105° phase shift demonstrated that the array can steer a beam wider than 80° and 100° respectively with a maximum gain of 7 dBi. The measurements, carried out in the MVG SG24, confirm that the prototype allows to reach the same scan angle observed in the simulations, but highlight a significant decrease in gain of 5 dB, due to the loss introduced by the four phase shifters and the port divider.

Poster_03.29 ***Performance Evaluation for Bi-directional Optical Fiber Link Transceiver for Antenna Measurement from 1 to 6 GHz***

Satoru Kurokawa (National Institute of Advanced Industrial Science and Technology, Japan)

We have already developed an antenna measurement system using bi-directional radio over fiber transceiver system from 1 GHz to 6 GHz. Our proposed system consists of bi-directional optical fiber link transceiver with microwave directional coupler that can extend the port of vector network analyzer. Our proposed system can measure S-parameters in full 2-port calibration from 1 to 6 GHz with less than 0.1 dB linearity for 40 dB attenuation measurement of vector network analyzer. In this paper, we show some advantage for antenna transmission coefficient and reflection coefficient measurement that compare with using our proposed system and using coaxial cable results for double ridged guide horn antenna from 1 to 6 GHz.

Poster_03.30 ***Design of Beam-Steerable Array for 5G Applications Using Tunable Liquid-Crystal Phase Shifters***

Anastasis C Polycarpou, Nectarios Papanicolaou and Marios Nestoros (University of Nicosia, Cyprus)

In this paper, we propose a new design concept of a beam-steerable, two-element array of microstrip patch antennas for 5G smartphone applications. The main beam is steered toward different directions through the use of a tunable phase shifter based on nematic liquid crystals (N-LC). The relative phase introduced at the input terminals of the two patch antennas is controlled through a bias voltage between 0 and 10 Volts. This external bias voltage changes the orientation of the LC molecules inside a cavity underneath the microstrip line, thus affecting the dielectric constant of the material, and effectively, the time delay. The antennas are fed through a feed network of microstrip lines. This design was optimized to provide impedance matching and low reflection coefficient. Simulation results using ANSYS HFSS reveal that the main beam can be switched toward different directions through the use of a low-intensity, low-frequency AC voltage that is applied externally between the microstrip line of the phase shifter and the common ground.

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Room: Oral Sessions: S2 – Warszawa

Chairs: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia), Andrzej A. Kucharski (Wroclaw University of Technology, Poland)

15:00 ***Compact Antenna Test Ranges: The Use of Simulation and Post-Processing Techniques in Support of 5G OTA Testing***

Stuart F Gregson (Queen Mary, University of London, United Kingdom (Great Britain)); Clive Parini (Queen Mary University of London, United Kingdom (Great Britain))

The Compact Antenna Test Range (CATR) is a long established, general purpose, wide-band, test methodology for acquiring far-field radiation characteristics within comparatively small test volumes [1]. By projecting an image of the CATR feed at infinity through field collimation, typically achieved by means of reflection, the CATR synthesizes the type of wave-front that would be incident on the antenna under test (AUT) if it were instead located at a position very much further away from the feed than is actually the case. By recording the coupling of this collimated pseudo plane-wave into the AUT for different orientations, we may obtain the classical measured "far-field" radiation pattern in real-time. Thus, the quality of the CATR pattern measurement is primarily determined by the uniformity and purity of the phase and amplitude of the pseudo plane-wave [2, 3, 4]. Thus, the performance of the range is largely, but not completely, crystallized at the time that the reflector and feed are fabricated and installed with scope for a posteriori performance improvements being relatively limited. However, even here, uses of advanced post-processing techniques have recently been shown to provide worthwhile benefits to the facility-level uncertainly budget and crucially, these too can be verified and developed in conjunction with electromagnetic simulation [1]. Thus, the successful development and deployment of CATRs has, necessarily, been predicated upon a corresponding development in the speed, accuracy and sophistication of the attendant CATR electromagnetic simulation software. Recent developments in CATR simulations have enabled the design and realization of increasingly complex and ever more efficient CATR assemblies that span progressively wider frequency ranges. These end-to-end simulations, which increasingly harness and rely upon parallel processing architectures, can

now be used to determine the impact of the precise CATR design on over-the-air (OTA) communications system parameters. This therefore paves the way for the design and development of CATRs that are fully optimized for the test, calibration and OTA measurement of demanding mm-wave massive multiple input, multiple output (MIMO) backhaul antenna systems. This is particularly important as interest has largely shifted away from traditional antenna performance metrics and instead is focusing on communication system figures of merit [5, 6]. Similarly, sophisticated post processing techniques now enable communication system level parameters such as far-field error vector magnitude (EVM), bit error rate (BER), signal-to-interference-plus-noise-ratio (SINR), etc. to be derived conveniently and efficiently from conventional ranges without the need for additional, expensive, specialist RF instrumentation. This paper presents an introduction to the CATR, the simulation and data post-processing highlighting some of the more significant developments while focusing on those aspects that are most pertinent to modern communication systems which are essential for the successful roll-out of 5G.

15:40 ***Millimeter-wave Technology and Research Trends for 5G Access and Wireless Transmission Applications An Industry View***

Renato Lombardi (Milan Microwave Competence Center, Italy)

High interest in millimeter-wave bands has risen in the recent years due to the enormous amount of under-utilized bandwidth that lies in this part of the electromagnetic spectrum. The significant advantages offered by the propagation characteristics in terms of frequency re-usability and large channel bandwidths, make millimeter-wave suitable for the very high capacities required by 5G enhanced Mobile BroadBand (10 Gpbs peak throughput and 10 Mbps/m2) both for the Radio Access Network and the Backhaul. The millimeter-wave bands can be suitably used for the access networks to increase the throughput to the User Equipment and the backhaul/front-haul of the base stations. At the same time the use of millimeter-wave bands, thanks to very compact antenna size that makes products ``blend'' in the environment, allows the densification of the cells in dense urban scenarios. 5G key requirements driving evolution of mobile access and wireless x-haul to millimeter-wave and sub-millimeter ranges Analysis of the most important requirements of 5G to drive the trends and technology at (sub-) millimeter-wave bands for wireless backhaul / front-haul network ▒ Application scenarios and potential bands for 5G at millimeter-wave ▒ Massive MIMO architectures comparison ▒ how backhaul can meet the demand of capacity and network densification ▒ new spectrum above 90 GHz and innovative ways to use it ▒ technology challenges and research directions Millimeter-wave access Since the beginning, large antenna arrays have been exploited for radar applications in order to achieve very high spatial resolution, beamforming and null steering. This trend has been recently introduced to communication systems too, in order to provide highly-directive beams as a means to both reduce interference and increase the overall capacity, allowing spectral reuse through spatial diversity. Nowadays the big challenge is not only related to the maximization of the overall system performance - which has been proven to be very effective when considering full-phased/full-digital architectures - but is mainly focused on the economic side: the real goal is to keep cost and energy consumption sufficiently low to obtain affordable products. In this invited talk it will be presented an overview of some techniques that can be adopted to design energy- and cost-efficient antenna arrays for millimeter-wave wireless systems (mm-Waves), which - having instantaneous bandwidths of hundreds of MHz to GHz - are seen as promising technology for meeting the exploding capacity requirements of 5G (and beyond) communication networks. Millimeter-wave backhaul Research activities in the D-Band (130 to 175 GHz) for outdoor backhaul applications ▒ Standardization status ▒ Technology overview (semiconductor trends) ▒ MMIC, Antenna, Engineering solutions ▒ Propagation model from field trials results

Inv_02 Tue: Inv_02 Invited Session 2

TOP

Other / Regular Session / Propagation

Room: Oral Sessions: S3-A – Gdansk

Chairs: Dirk Heberling (RWTH Aachen University, Germany), Ronan Sauleau (University of Rennes 1, France)

15:00 ***Radiowave Propagation Analysis and Measurements for Wide Area Radio Networks Planning and Optimization***

Dariusz P. Wiecek (National Institute of Telecommunications, Poland)

Radiowave propagation analysis is a very important issue especially in cases of long distances connections - where many different propagation effects can have big influence on proper reception conditions and possibility of establishing planned services with required QoS. In the paper influence of effects coming from propagation modelling to the networks plans, international frequency coordination process and operators contracts obligations are discussed. Basis of propagation modelling cases used for wide area radio networks planning and optimization are presented showing also backgrounds of the modelling. Activities performed in the area of radiowave propagation measurements and their modelling performed within NIT radio spectrum research group is also presented. Discussion on background of the models issues and proper adaptation of them to some real scenario deployment are presented with propagation tools characterizations giving presented in some cases special networks planning effects. Results of propagation measurements campaign performed in Poland and example of incorporation and adaptation they into the models are described. Limitation of some actual popular propagation models as, e.g. ITU-R P.1546-5 used with very detailed (e.g. 1x1m) digital elevation data maps and validation of the propagation models in such conditions are also presented showing unrealistic coverage results with such very detailed analysis. Examples of some practical networks plans and their dependence on appropriate propagation models developed for different commercial operators cases were also discussed. Conclusions present current evolution and limitation of development software tools for the radiowave propagation analysis.

15:40 ***Electromagnetics Education and Its Future and Challenges***

Branislav Notaros (Colorado State University at Fort Collins, USA)

Electromagnetic theory is a fundamental underpinning of technical education, but, at the same time, one of the most difficult subjects for students to master and for instructors to teach. This material is extremely abstract and mathematically rigorous and intensive, and students find it rather difficult to grasp, which is not unique to any particular school or department, country, or a geographical region of the world. On the other hand, the importance of electromagnetics, as a fundamental science and engineering discipline, to technical education can hardly be overstated. In addition, electromagnetics has immediate impacts on a great variety of cutting-edge applications in antenna, propagation, microwave, radar, microelectronics, and lightwave technologies, and a comprehensive knowledge and firm grasp of electromagnetic fundamentals is essential for students in a number of undergraduate and graduate courses, as well as for engineering graduates as they join the workforce, now and in the future. There are great problems and challenges in the methodology and practice of electromagnetics teaching and learning related to the diversity and nonuniformity of curricular contents, teaching/learning methods, pedagogical goals, instructor expertise, areas of emphasis and desired outcomes of the course or sequence of courses, and the available time, as well as to the average decline in student preparedness and their interest and motivation for fields and waves courses. This talk will address these problems and challenges and discuss some examples of general approaches to overcoming these difficulties, with outlooks for the future, and with special attention to antennas and propagation relevance and perspective. It will present some strategies for active and problem-based learning including interactive discussion - using realistic examples, with the primary goal to aid understanding and develop true problem-solving skills for the students. It will also outline a geometrical approach to teaching and learning vector calculus as applied to electromagnetics, as an intuitive and visual alternative to formal, purely "algebraic" approach. In addition, the talk will discuss an integrated approach to electrical-engineering education that incorporates computer-assisted MATLAB-based instruction and learning into the electromagnetics courses, using a comprehensive collection of MATLAB computer tutorials, exercises, projects, and codes, as a modern tool for learning electromagnetics via computer-mediated exploration and inquiry. This approach introduces students to MATLAB programming of electromagnetic fields and waves, in addition to passive demonstrations and visualization of fields. Another approach to be presented involves utilization of conceptual questions and interactive online quizzes for assessment of class pre-work and enhancement of engagement of students in electromagnetics learning modules, to enable the implementation of a partially flipped classroom instruction. Namely, best practices in engineering education require the students to intensely engage in the assigned pre-work, which must be meaningfully motivated and assessed. Conceptual questions can also be applied to various modalities of active and collaborative teaching and learning. The impacts of all approaches on students' learning are analyzed and assessed in multiple ways. The talk will attempt to give some collaborative thoughts on the future of electromagnetics education based on discussions with colleagues worldwide.

Tuesday, April 2 16:50 - 18:30

CS25 Electromagn Quant World: CS25 Electromagnetics in a Quantum World

TOP

Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: A1 - Gdynia

Chairs: Iñigo Liberal (Public University of Navarre, USA), Richard Ziolkowski (University of Technology Sydney, Australia & University of Arizona, USA)

16:50 ***Designing the Bandwidth of Single-Photon Sources with Classical Antenna Techniques***

Iñigo Liberal (Public University of Navarre, USA); Iñigo Ederra (Universidad Pública de Navarra, Spain); Richard Ziolkowski (University of Technology Sydney, Australia & University of Arizona, USA)

We discuss the role of the classical electromagnetic theory concept of reactive interactions on determining the bandwidth of a single-photon source. Typically, quantum emitters operate in the weak-coupling regime where the bandwidth of the emission spectrum is simply proportional to their decay rates. However, we introduce a first-order correction to the emission spectrum, demonstrating that its bandwidth is also directly affected by the dispersion properties of the reactive interactions of the quantum emitter with its environment. This correction is particularly important in the intermediate region bridging the weak and strong coupling regimes. As an example of the applicability of this theory, we study the behaviour of a quantum emitter decaying through a coupled two-cavity system. Our results suggests that this setup could be utilized for the design of efficient, but narrowband single-photon sources.

17:10 ***On Hydrodynamic Models for the Nonlocal Optical Response of Deep-Nanometer Scatterers***

Mario Kupresak and Xuezhi Zheng (Katholieke Universiteit Leuven, Belgium); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium); Victor V. Moshchalkov (Katholieke Universiteit Leuven, Belgium)

As light-matter interaction at the deep-nanometer scale has recently attracted much attention, several hydrodynamic models (HDM) are extensively studied, tackling quantum mechanical effects. These models essentially rely on the hydrodynamic equation of motion and additional boundary conditions (ABC), accounting for the motion of the free electron gas in metals. In this work, four hydrodynamic models are compared: the hard wall hydrodynamic model (HW-HDM), the curl-free hydrodynamic model (CF-HDM), the shear forces hydrodynamic model (SF-HDM), and the quantum hydrodynamic model (Q-HDM), with the Sauter ABC, the Pekar ABC, the specular reflection ABC, and the quantum hydrodynamic ABC, respectively. This is performed through the near and far field characterization of a canonical spherical nanoparticle with a nonlocal material parameter. The results reported demonstrate that the optical features investigated may be significantly altered by using different hydrodynamic approaches.

17:30 ***Introducing Quantum Tunneling Optimization in Electromagnetics, the Constraint Relaxation Approach***

Theodoros Kaifas, Dimitrios G. Babas and Sotirios Goudos (Aristotle University of Thessaloniki, Greece)

There are two major categories of optimization algorithms employed in em problems. They are the gradient based and the metaheuristic, (mainly evolution), based algorithms. In the work at hand we use both gradient and metaheuristic algorithms but the latter are not evolutionary. The contributed idea is based on another paradigm drawn from the laws of quantum physics and entails

the integration of quantum tunneling concept into a basic gradient search. It is well known in Quantum Mechanics that, Quantum Tunneling transforms local barriers into (semi-) transparent boundaries allowing the gradient search to pass through and continue to the global extremum. To the authors' knowledge this is only physical phenomenon able to achieve the non-convex to convex transformation, (by going through and not over the barriers), and as such it deserves thorough study. Our work proves that gradient search equipped with quantum tunneling can be pulled out of the basin of a local extremum to provide high quality optimization results. In the current study we contribute the introduction of quantum tunneling in electromagnetics under the Constraint Relaxation Approach and provide proof of its potential.

17:50 ***Bridging the Gap Between Electromagnetic and Quantum Transport: Developing a Multi-physics, Multi-scale Computational Platform***

Luca Pierantoni (Università Politecnica delle Marche, Ancona & Istituto Nazionale Fisica Nucleare (INFN), Italy); Giuseppe Vecchi (Politecnico di Torino, Italy)

This paper presents the development of a multi-scale, multi-physics computational platform necessary for the design of disruptive devices based on smart nano-structured materials technologies, for a wide area of applications, from microwave to photonics, in the field of interests of high-tech industries

18:10 ***Scattering by an Electrically-Small Circular Aperture in a Conducting Screen Using the Gegenbauer Polynomial Expansion***

Anastasis C Polycarpou and Marios Christou (University of Nicosia, Cyprus)

In this paper, we used the electric vector potential formulation, along with the equivalence principle and image theory, to calculate the scattered fields by a sub-wavelength circular slot in an infinite conducting ground plane. The formulation begins with the radiation integrals of the established magnetic current density in the aperture due to an incident plane wave of a given polarization and angle of incidence. The quasi-static magnetic current density in the aperture is based on the Bouwkamp model published in his monograph on diffraction theory in 1950. This paper provides significant added value to an earlier work published by the authors as it allows evaluation of the radiation integrals for observation points off the axis of the aperture using the Gegenbauer polynomial expansion of the Green's function terms of the form 1/R^a. Taylor-series expansion of the exponential exp(-jkR) is also used in this work in order to obtain accurate results for the scattered fields in the intermediate and far-field observation regions. The formulation presented herein is valid only for the case where the observation distance from the origin of the coordinate system is larger than the radius of the aperture; i.e., $r>a$, where a is the radius of the aperture. Comparisons between analytical results obtained using the proposed formulation and data obtained using numerical integration illustrate the accuracy of the underlined approach.

CS41 Advanced Ant Nanosat Apps: CS41 Advanced Antenna Concepts for Nanosatellite Applications

TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Nacer Chahat (NASA-JPL, Caltech, USA), Maxime Romier (CNES, France)

16:50 ***Design of a Dielectric Resonator Antenna with a Customized Dielectric Constant Based on Zirconia***

Marc Thevenot (XLIM-University of Limoges, France); Cyrille Menudier (XLIM UMR 7252, Université de Limoges/CNRS, France); Nicolas Delhote (XLIM - UMR CNRS, University of Limoges, France); Olivier Tantot (XLIM - University of Limoges, France); Nicolas Capet (ANYWAVES FRANCE, France); Maxime Romier (CNES, France)

Ceramic materials offer interesting characteristics for high-performance RF developments. Among the constraints, it is difficult to obtain a specific dielectric constant without important changes in the process and raw material. In this contribution, the dielectric constant of zirconia is changed thanks to an additive manufacturing process. It is used to build an elementary lattice derived from crystalline structure. A dielectric resonator antenna has been successfully designed and measured with the proposed approach.

17:10 ***Collocated Compact UHF and L-Band Antenna for Nanosatellite ARGOS Program***

Rémi Fragnier, Lise Feat, Romain Contreres, Baptiste Palacin, Kevin Elis, Anthony Bellion and Gwenn Le Fur (CNES, France)

This paper presents a miniature dual-feed UHF and L-band antenna designed for the Argos Neo data collection program. Intended to be integrated into the 12U ANGELS nano-satellite, its footprint and volume have been miniaturized to use a volume lower than 2U while providing optimal performances at 400MHz and 1.7GHz. Key design elements are presented, as well as simulated performances using CST Microwave Studio and measured performances.

17:30 ***An Innovative Deployable VHF/UHF Helical Antenna for Nanosatellites***

Tao Huang, Juan Reveles, Vinoth Gurusamy, Quentin Harrington and Vincent Fraux (Oxford Space Systems, United Kingdom (Great Britain))

This paper presents an innovative design of a deployable VHF/UHF band helical antenna for nanosatellites. The antenna is designed to stow into a space smaller than 1U (100x100x100 mm) of a 3U nanosatellite in transportation and launch stage, then deployed into full operational space of 180 mm in diameter and 300 mm in length when the satellite reaches to designated orbit. The helices are supported and deployed by a central boom which is controlled and driven by a step motor. This ensures a reliable deployment and a minimum disturbance to the space craft during deployment. The deployable helical antenna presented in this paper produces a circular-polarized axial mode radiation pattern, and this is achieved by the combination of winding sense of helices and the feeding-phase and amplitude of the feed Balun. There is no ground plane in this design, which is required normally in a conventional helical antenna.

17:50 ***Compact 3D Printed Antenna Technology for Nanosat/Cubesat Applications***

Benedikt Byrne (ANYWAVES, France); Nicolas Capet (ANYWAVES FRANCE, France)

This paper presents a new technology enabling the design of high performance miniature antennas by using additive manufacturing of ceramic materials. Based on a patented technology, the dielectric material is structured in 3D to obtain the desired effective permittivity ceff. As an example, a patch antenna with a 3D printed substrate has been designed. Simulated as well as measured results are given and compared one to each other.

18:10 ***X/Ka-band One-Meter Deployable Mesh Reflector for Deep Space Network Telecommunication***

Nacer Chahat (NASA-JPL, Caltech, USA); Jonathan Sauder (NASA-JPL / Caltech, USA); Matthew Mitchell, Neal Beidleman and Gregg Freebury (Tendeg LLC, USA)

A deployable one meter mesh reflector compatible with 12U-class CubeSat is introduced for telecommunication. It is compatible with NASA's deep-space network (DSN) at X-band (i.e., uplink: 7.145-7.19 GHz; downlink: 8.4-8.45 GHz) and Ka-band frequencies (i.e., uplink: 34.2-34.7 GHz; downlink: 31.8-32.3 GHz). Three right-handed circularly polarized (RHCP) antennas, both transmit and receive, are introduced here: X-band only, Ka-band only, and X/Ka-band.

CS38 Machine Learning for Applied EM: CS38 Trends and Advances in Machine Learning for Applied Electromagnetics

TOP

Future Applications / Convened Session / Propagation

Room: Oral Sessions: S3-A – Gdansk

Chairs: Sotirios Goudos (Aristotle University of Thessaloniki, Greece), Andrea Massa (University of Trento, Italy), Marco Salucci (ELEDIA Research Center, Italy)

16:50 ***Microwave Inversion for Sparse Data Using Descent Learning Technique***

Rui Guo, Zekui Jia, Xiaoqian Song, Maokun Li, Fan Yang and Shenheng Xu (Tsinghua University, P.R. China); Aria Abubakar (Schlumberger-Doll Research, USA)

With limited observed data, we apply supervised descent method for two-dimensional microwave imaging. This method first learns a set of descent directions for optimization in the offline training, and updates the reconstructed models in the online prediction. Prior information that cannot be expressed in mathematical ways can be incorporated into the inversion by adjusting training models. In addition, the learned descent directions help to skip some local minima and accelerate online computational speed. To reduce the ill-posedness caused by sparse data, we parameterize the model space and apply model-based inversion. Numerical examples show that the model-based supervised descent inversion reconstruct the unknowns well with prior information flexibly incorporated, and the online computational speed is fast.

17:10 ***Innovative Machine Learning Approaches for Nondestructive Evaluation of Materials***

Roberto Miorelli and Christophe Reboud (CEA LIST, France); Marco Salucci (ELEDIA Research Center, Italy)

This paper deals with a machine learning framework dedicated to nondestructive testing applications, in view of flaws detection and characterization. A supervised learning strategy is used on a training set made of characteristic features, extracted from eddy current testing (ECT) and ultrasounds testing (UT) signals. The approach is first presented and the key role of the feature extraction by means of Partial Least Squares is highlighted. Then, the performance of the proposed data-fusion approach, in terms of both localization and characterization, is compared to that of similar approaches exploiting one inspection technique only.

17:30 ***Modelling Received Signal Power in Modern Mobile Communications with UAVs Using Ensemble Learning***

Sotirios Goudos (Aristotle University of Thessaloniki, Greece); George Tsoulos and Georgia E. Athanasiadou (University of Peloponnese, Greece)

In this paper, we apply ensemble learning methods for the prediction of received signal strength (RSS) in mobile communications The training set is obtained by experimental data measurements taken from a unmanned aerial vehicle (UAV). We model the RSS using two different ensemble methods. One of these achieves better performance than a neural network in previous work. In this context, the produced results are compared to measurements using representative performance indices and exhibit satisfactory accuracy.

17:50 ***MQC10-BBO Optimization Applied to Multi-Beam Antenna Design***

Paola Pirinoli, Michele Beccaria and Andrea Massaccesi (Politecnico di Torino, Italy)

In this paper, a procedure for the design of multi-beam antennas based on the use of the MQC10 Biogeography Based Optimization (MQC10-BBO) algorithm is presented. Preliminary results obtained by its application to multi-beam reflectarrays are here presented, while at the conference those relative to other configurations will be also discussed.

18:10 ***Bearing Estimation with Randomized Linear Arrays***

Arjun Gupta and Manel Martínez-Ramón (University of New Mexico, USA); Christos Christodoulou (The University of New Mexico, USA); Jose Luis Rojo-Alvarez (University Rey Juan Carlos, Spain)

The source location estimation of multiple signals with a randomized array is implemented in this paper. The incoming signal is sampled non-uniformly in the spatial domain using randomly scattered antenna elements on a linear axis. Mercer's kernel interpolation is performed to map the outputs of the actual array elements in randomized positions to the elements of a virtual uniform array. The sampled signal is passed through the proposed filter and an uniformly sampled equivalent of the received signal is obtained. The interpolated signal is further processed through root-MuSiC to obtain the angles of arrivals of the signals. The mean squared error (MSE)of the proposed estimator is compared to the MSE of the least squares interpolation technique, simulation results are detailed and discussed.

F_A02 Slot-Guid-Leaky Ant: F_A02 Slotted-, guided- and leaky- wave antennas

TOP

Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Yevhen Yashchyshyn (Warsaw University of Technology, Poland), Dirk Heberling (RWTH Aachen University, Germany)

16:50 ***Wide Band Single-Pole Circularly-Polarized Fabry-Perot Antenna***

Antoine Calleau (Universite de Rennes 1, France); María García-Vigueras (IETR-INSA Rennes, France); Hervé Legay (Thalès Alenia Space, France); Ronan Sauleau (University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

A novel approach is here presented, to design wide band circularly-polarized Fabry-Perot antennas. The proposed method is based on a Green's function approach. It is proven that a single leaky-wave mode is sufficient to generate circular polarization over a wide 3 dB axial ratio bandwidth. Three antennas with different maximum directivity are compared. It is shown that the axial ratio bandwidth does not vary with the directivity peak value, thanks to the excitation of a single leaky-wave mode. The study is validated by an antenna design providing 23% bandwidth. The proposed approach is very appealing for low-directive antennas with wide 3 dB axial ratio bandwidth.

17:10 ***Radiating Properties of 1-D Bidirectional Leaky-Wave Antennas***

Walter Fuscaldo (Sapienza University of Rome, Italy); David R. Jackson (University of Houston, USA); Alessandro Galli (Sapienza University of Rome, Italy)

We analyze radiation from \emph{bidirectional} one-dimensional leaky-wave antennas (1-D LWAs), from an original perspective. As is known, when the aperture is infinite, the radiation pattern changes considerably for certain combinations of the phase and the attenuation constants. These specific values identify the boundaries between different radiating regimes. In this work, we thoroughly explain the evolution of the beam through all the radiating regimes, and then evaluate its beamwidth with original analytical formulas. The relevant case of a finite-size aperture is considered as well. In this case, we show that the boundaries between the radiating regimes change as the radiation efficiency changes. The evolution of these boundaries as a function of the radiation efficiency is found by numerical means. These results allows for a rigorous and comprehensive description of the radiating behavior of practical 1-D bidirectional LWAs.

17:30 ***Accurate Formulas for the Beamwidth of 1-D Bidirectional Leaky-Wave Antennas***

Walter Fuscaldo (Sapienza University of Rome, Italy); David R. Jackson (University of Houston, USA); Alessandro Galli (Sapienza University of Rome, Italy)

In this work, we accurately evaluate the beamwidth of one-dimensional (1-D) bidirectional leaky-wave antennas (LWAs) radiating at broadside. Indeed, existing formulas neglect the effect of the aperture truncation, which affects the exact value of the beamwidth for practical realizations of 1-D LWAs. By exploiting a well-established theoretical framework, we find an approximate, but still accurate analytical formula for evaluating the beamwidth of finite-length 1-D bidirectional LWAs radiating at broadside. The comparison with numerical results confirm the accuracy of the proposed formula, whereas the comparison with previous formulas confirm its relevance for accurate LWA design.

17:50 ***Phase-Equalized Periodic Series-Feeding Network from Structural Asymmetry***

Amar Al-Bassam and Dirk Heberling (RWTH Aachen University, Germany); Christophe Caloz (Ecole Polytechnique de Montreal, Canada)

All open 1D-periodic structures with symmetric unit cell exhibit abrupt variation in their physical parameters at the equi-phase frequency (Γ point of reciprocal space), which usually results in undesirable radiation characteristics. This is the case for leaky-wave antennas (LWAs), but also for Series Feeding Networks (SFNs), where radiation could be considered as energy propagation into the feeding ports. We show here that the response of a periodic SFN can be equalized versus frequency through the equi-phase frequency, just as that of LWAs, by the introduction a proper amount of asymmetry in its unit cell. Moreover, we illustrate this fact with the example of a millimeter-wave 77 GHz array of antipodal Vivaldi antennas feed by such an asymmetric SFN.

18:10 ***3D Printed Antennas Metallized Using Conductive Paint at X-Band***

Shaker Alkaraki (Queen Mary University Of London, United Kingdom (Great Britain)); Yue Gao (Queen Mary University of London, United Kingdom (Great Britain)); Samuel Stremsdoerfer (Jet Metal Technologies, France); Edouard des Gayets (Jet Metal Technologies, Belgium); Clive Parini (Queen Mary University of London, United Kingdom (Great Britain))

This paper presents a design and prototypes of 3D printed antennas that operate at X-band and metallized using simple and low cost methods. The proposed 3D printed antennas operate at 10 GHz and they are metallized using different low cost conductive paint. The first antenna is metallized using conductive copper paint, while the second and the third antennas are metallized using silver paint. The performance of the proposed antennas is evaluated and the measured results of the prototypes show a good agreement with the simulation results, especially in the case of the antennas that metallized using silver paint. Measured results show descent and high gain performance of the fabricated prototypes. In addition, results show that the proposed antennas have wide impedance bandwidth of more than 10%, with radiation in the boresight direction with low side lobe level performance.

CS35 Ant & Radio Channels: CS35 Assessment and modelling of antennas and radio channels jointly

TOP

Cellular Communications / Convened Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany), Alain Sibille (Telecom ParisTech, France)

16:50 ***A Clustering Algorithm Based on Joint Kernel Density for Millimeter Wave Radio Channels***

Binlin Guo (Beijing University of Posts and Telecommunications, P.R. China); Lei Tian (Beijing University of Posts and Telecommunications & Wireless Technology Innovation Institute, P.R. China); Jian Zhang (Beijing University of Posts and Telecommunications, P.R. China); Yuxiang Zhang (Beijing University Of Posts And Telecommunications, P.R. China); Li Yu and Jianhua Zhang (Beijing University of Posts and Telecommunications, P.R. China); Zheng Liu (China Academy of Telecommunication Research, P.R. China)

Cluster-based channel modeling has gradually become a trend, since it can balance modeling accuracy and complexity. In this paper, we propose a density-based clustering algorithm to cluster multipath components (MPCs), which considers the statistical characteristics of the parameters when calculating the density with joint kernel equation. To validate the performance of the algorithm, both simulation and a millimeter-wave based urban-microcell channel measurement are performed. Compared with KPowerMeans, the results of simulation show that the proposed algorithm can identify clusters with a higher success rate validated by Fowlkes-Mallows score (FMI), and measurement-based clustering results have better intra-cluster compactness and inter-cluster separation validated by Calinski-Harabasz (CH) index and Davies-Bouldin (DB) criterion. Furthermore, the proposed algorithm does not require preset the number of clusters, which makes it more intelligent.

17:10 ***Far-field Reference Distance Criteria for Compact OTA Testing Ranges***

Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

Analyzed are three criteria for the computation of a reference distance marking the start of the far-field region in antenna measurements. The analysis is based on a correction factor for the Friis formula at boresight in the Fresnel zone. Closed form equations are obtained as a function of frequency, the gains of the transmit and receive antennas and a userdefined accuracy factor. Based on the above a far-field reference distance similar to the Fraunhofer distance criterium is defined. The presented results will be essential to design cost-efficient characterization of wireless devices of any size with user-defined accuracy.

17:30 ***Array Factor Derived from a Correlation Matrix***

Doug Reed and Alfonso Rodriguez-Herrera (Spirent Communications, USA)

5G utilizes antenna arrays in every standardized configuration. Both ray-based and correlation-based modeling are used to specify a propagation condition or evaluate measured data in conjunction with antenna arrays. This paper presents a method to estimate the array factor or beam pattern that is observed from an antenna array for a given channel model using a correlation matrix and compares to the theoretical array factor. Both a simple ULA and a Planar Array is used for evaluation. Also, the use of ray based geometric modeling is compared. This analysis also includes the effect of angle spread, providing a new perspective on how the channel model interacts with the antenna array.

17:50 ***Joint Antenna and Channel Modelling for Communication in Metallic Kitchen Environments***

Brecht De Beelde (Ghent University & IMEC/WAVES, Belgium); Nico Podevijn (University of Ghent, Belgium); David Plets (Ghent University - imec, Belgium); Emmeric Tanghe (Ghent University, Belgium); Luc Martens (Ghent University-IMEC, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper presents a study on the joint antenna and channel modelling for communication in metallic kitchen environments. It allows characterizing and optimizing the wireless communication between the cooking pot and the kitchen hood in a smart kitchen. The delay and path loss characteristics of the wireless channel are obtained from channel sounding measurements. The influence of the metallic pot on the antenna is taken into account by performing measurements with and without pot. The channel sounding measurements show a small delay spread and path loss values that are close to the free space path loss for a Line-of-Sight setup but up to 30 dB higher for different setups. The measurements with pot show lower losses, due to a more directive radiation pattern of the antenna when placed next to metal. Path loss and small scale fading margins are used for link budget calculations.

18:10 ***Self-user Shadowing Effects of Millimeter-Wave Mobile Phone Antennas in a Browsing Mode***

Mikko Heino (Aalto University, Finland); Clemens Icheln (Aalto University & School of Electrical Engineering, Finland); Katsuyuki Haneda (Aalto University, Finland)

In this paper a simulation method for estimating the shadowing effect of a human at millimeter-wave frequencies is presented. The shadowing effect is studied at 28 GHz and at 60 GHz for the case when a user holds a mobile phone. Both single-hand grip and two-hand grip browsing scenarios are studied with a dual-polarized mobile phone antenna. We use the integral equation method combined with a surface-impedance-based material model for the human. It is found that at 28 GHz the human body causes shadowing of up to 22 dB behind torso and head of the human, while at 60 GHz shadowing is up to 30 dB. On the other hand, in some other directions the human body effectively increases radiation by up to 5-10 dB through scattering and reflection. The novel method using a detailed human shadowing model is useful in evaluating mm-wave mobile terminal antenna performance in realistic multipath propagation environments.

C_A07 Ref & Transmit Array: C_A07 Reflect arrays and transmit arrays

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Giuseppe Di Massa (University of Calabria, Italy), Alberto Reyna (Autonomous University of Tamaulipas, Mexico)

16:50 ***Transmitarray Antenna with Integrated Frequency Multiplier for High-speed D-band Communications in Low-cost PCB Technology***

Francesco Foglia Manzillo (CEA-LETI, France); Antonio Clemente (CEA-LETI Minatec, France); Benjamin Blampey and Gabriel Pares (CEA-LETI, France); Alexandre Siligaris (Cea, Leti, Minatec, France); Jose Luis Gonzalez Jimenez (CEA LETI, France)

This contribution presents the design and experimental validation of a high-gain D-band fixed beam transmitarray excited by a compact antenna-in-package. Both the planar lens and the focal source are fabricated using standard printed circuit board (PCB) technology. An eight-fold frequency multiplier is co-integrated on the source and feeds a 2x2 patch array. The transmitarray is designed using eight phase states (i.e. 3 bits of phase quantization) and comprise 1600 unit cells (40x40). As per simulations, the -3 dB gain bandwidth ranges from 114 GHz to 144 GHz, with a peak gain of 29.5 dBi. An excellent agreement between measured and simulated radiation patterns is observed. The proposed concept represents a cost-effective solution for future wireless networks operating beyond 100 GHz.

17:10 ***V-Band Beam-Switching Transmitarray Antenna for 5G MIMO Channel Sounding***

Tuyen Pham (University of Rennes 1 & Institut d'Électronique et de Télécommunications de Rennes UMR CNRS 6164, France); Jialai Weng (IMT - Atlantique, Brest, France); Trung Kien Pham (University of Rennes 1 & IETR, France); Francois Gallée (IMT - Atlantique, Brest, France); Ronan Sauleau (University of Rennes 1, France)

Beam steering antennas are attractive solutions for beamforming channel sounding applications and multi-beam massive multiple-input multiple-output (M-MIMO) systems. The antenna proposed here consists of a transmitarray antenna fed by a patch antenna array operating in V-band (57 - 66 GHz). The transmitarray is made in PCB technology with 8-phase state unit-cells. The focal array is a four-patch array excited by a standard microstrip corporate feed network. The simulation results demonstrate a wide scan range (72°) with a peak gain of 22.9 dBi at broadside and with scan loss of about 4.2 dB in E-plane and H-plane for the most offset beams.

17:30 ***Broadband Dielectric Transmitarray with Scanning Capabilities***

Andrea Massaccesi, Paola Pirinoli, Valentina Bertana, Giorgio Scordo, Simone Marasso, Matteo Cocuzza and Gianluca Dassano (Politecnico di Torino, Italy)

In this paper, some preliminary results on the scanning capabilities of a dielectric, 3D-printable Transmitarray (TA) are presented. In a previous work, it was already proved that the TA presents a wide-band behavior, thanks to the use of an innovative dielectric unit-cell, composed of three layers: the central one has a square hole, whose constant size is changed to control the phase of the incident field; the two identical, external ones present a truncated pyramid hole, acting as a wide-band matching circuit. Here, it is shown that the behavior of the unit-cell stays almost the same for different angles of incidence, and this makes it particularly convenient for the realization of beam scanning antennas.

17:50 ***A Single Layer Dual Band/Dual Polarized Reflectarray Cell for 5G***

Sandra Costanzo, Francesca Venneri and Giuseppe Di Massa (University of Calabria, Italy)

A single-layer dual-band/dual-polarized reflectarray configuration is investigated for emerging 5G systems. A unit cell able to operate independently at two distinct frequencies within the Ka-band (28/38 GHz), in a dual-polarization mode, is designed by adopting two pairs of miniaturized fractal patches. The proposed cell allows to achieve an independent optimization of the phase at each frequency and polarization, showing negligible mutual coupling effects between the two bands. A reflectarray prototype is simulated demonstrating its ability in achieving arbitrary beam directions at each frequency, for both polarizations. Due to its compactness and versatility, the proposed unit cell is appealing for future 5G applications.

18:10 ***A 1-D Beam Scanning Planar Dielectric Lens Based on a Phase-Center Electrically Controllable Primary Feed***

Xin Guo (Ministerial Key Laboratory, JGMT, Nanjing University of Science and Technology, Nanjing, P.R. China); Wen Wu and Da-Gang Fang (Nanjing University of Science and Technology, P.R. China)

A primary feed with electrically controllable phase-center is proposed and utilized in a 1-D beam scanning planar dielectric lens. First, a method to synthesis design the feed with specific phase-center positions is demonstrated. Then, the physical realization of the feed is displayed. Finally, it is located at the focal plane of a well-designed 1-D planar dielectric lens, so as to obtain the beam scanning performance. The simulated results indicate that the beam scanning property has been observed and the largest scanning angle of the designed lens antenna is ±6° at 5.5 GHz. The proposed design theory and design method have thus been validated.

L_A01 Adaptive Reconf: L_A01 Adaptive and Reconfigurable Antennas

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Yi Huang (University of Liverpool, United Kingdom (Great Britain)), Patrizia Savi (Politecnico di Torino, Italy)

16:50 ***Electronically Steerable Parasitic Array Radiator Flush-Mounted for Automotive LTE***

Gerald Artner (Vienna University of Technology, Austria); Jerzy Kowalewski and Jude Atuegwu (Karlsruhe Institute of Technology, Germany); Christoph F Mecklenbräuker (Vienna University of Technology, Austria); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

A pattern reconfigurable antenna for 2.6GHz LTE is flush-mounted in a chassis antenna cavity. The driven element is a top-loaded monopole, that is steered based on the electronically steerable parasitic array radiator (ESPAR) principle. The radiation pattern can be configured in 45 degree steps, e.g. front, diagonal front-right, right, etc. The cavity prototype is made from carbon fiber reinforced polymer and includes a chassis mockup. Antenna performance is evaluated based on measured gain patterns, which show that the antenna retains its reconfiguration capabilities when it is flush-mounted. Further, a parametric measurement study with regards to antenna height inside the cavity is performed to investigate the option of mounting an electronics module underneath the antenna.

17:10 ***RSS-Based DoA Estimation with ESPAR Antennas Using Reduced Number of Radiation Patterns***

Michal Tarkowski (Gdansk University of Technology, Poland); Mateusz Rzymowski (Gdansk University of Technology & WiComm Center of Excellence, Poland); Krzysztof Nyka (Gdansk University of Technology, Poland); Lukasz Kulas (Gdansk University of Technology, Faculty of Electronics, Telecommunications and Informatics, Poland)

In this letter, we investigate how direction-of-arrival (DoA) estimation algorithms, which are designed for electronically steerable parasitic array radiator (ESPAR) antennas and rely solely on received signal strength (RSS) values recorded at antenna's output port, will perform when limited number of radiation patterns will be used. To this end we have inspected two algorithms, which are easily applicable in WSN nodes having simple and inexpensive transceivers and provide accurate results. Measurements conducted using a fabricated ESPAR antenna indicate that it is possible to limit the number of radiation patterns in DoA estimation procedure and still keep the original accuracy. Hence, depending on application, the time required for DoA estimation in WSN nodes using ESPAR antennas can be reduced from 50% up to 75%.

17:30 ***Electronically REconfigurable Superstrate (ERES) Antenna***

Luiza Leszkowska and Damian Duraj (Gdansk University of Technology, Poland); Mateusz Rzymowski (Gdansk University of Technology & WiComm Center of Excellence, Poland); Krzysztof Nyka (Gdansk University of Technology, Poland); Lukasz Kulas (Gdansk University of Technology, Faculty of Electronics, Telecommunications and Informatics, Poland)

In this paper, we propose Electronically REconfigurable Superstrate (ERES) antenna design to provide simple, yet effective, beam steering capabilities to increase connectivity between wireless sensor network (WSN) nodes. The proposed design involves the superstrate layer concept, proposed originally to increase gain of microstrip patch antennas. By grouping parasitic patches within the designed superstrate layer and introducing a switching circuit with PIN diodes, it has been possible to create sections that can be steered using only 4 digital input output ports. Simulation results indicate, that, by shortening each section independently to the ground, it is possible to steer the main antenna beam electronically. In consequence, the proposed antenna can successfully be used to improve connectivity in WSN nodes relying on inexpensive transceivers and operating in demanding industrial conditions.

17:50 ***SDR-Based DoA Estimation Using ESPAR Antennas with Simplified Beam Steering***

Przemyslaw Kwapisiewicz and Mateusz Groth (Gdansk University of Technology, Poland); Mateusz Rzymowski (Gdansk University of Technology & WiComm Center of Excellence, Poland); Lukasz Kulas (Gdansk University of Technology, Faculty of Electronics, Telecommunications and Informatics, Poland)

In this paper, we have presented results of the two most popular and accurate direction-of-arrival (DoA) estimation algorithms that may be implemented in a software-defined radio (SDR) unit equipped with electronically steerable parasitic array radiator (ESPAR) antenna, in which beam steering is performed in a simple and energy-efficient way. Both algorithms rely on IQ waveform samples recorded, for different main beam directions, at the antenna output port, from which information about both amplitude and phase of an unknown signal impinging the antenna has been extracted. Measurement results indicate, that, by using SDR-based calibration setup, it is possible to perform DoA estimation with less than a single degree precision, which, according to author's knowledge, is the best result available in the literature.

18:10 ***ESPAR Antenna for V2X Applications in 802.11P Frequency Band***

Damian Duraj (Gdansk University of Technology, Poland); Mateusz Rzymowski (Gdansk University of Technology & WiComm Center of Excellence, Poland); Krzysztof Nyka (Gdansk University of Technology, Poland); Lukasz Kulas (Gdansk University of Technology, Faculty of Electronics, Telecommunications and Informatics, Poland)

In this paper an Electronically Steerable Parasitic Array Radiator (ESPAR) antenna prototype for vehicle-to-everything (V2X) applications is proposed. The motivation of this work was to adapt ESPAR antenna concept widely used in Wireless Sensor Networks to improve connectivity and security in V2X communication system. Designed model was optimized for 802.11p frequency band and includes steering circuits based on fast and low-power UltraCMOS SPDT switches. Proposed antenna has compact size and provides unique directional radiation patterns for 360° area scanning. Theoretical and simulated results have been discussed in order to evaluate the antenna parameters with respect to V2X communication system requirements.

CS8 Coex Wind Turb & Radar: CS8 Recent Research on the Coexistence of Wind Turbines and Radar Systems

TOP

Radars / Convened Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Remi Douvenot (ENAC, France), Frank Weinmann (Fraunhofer FHR, Germany)

16:50 ***Wind Turbine Angular Velocity Estimation Using Polarimetry***

Chrysovalantis Kladogenis (Technological University of Delft, The Netherlands); Hans Driessen (Thales Nederland BV, The Netherlands); Oleg Krasnov (Delft University of Technology, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

Wind turbines usually cause significant interference in the conventional radar operations which might degrade the detection capabilities of a radar system. Wind turbines do not only block the radar beam focusing on a specific target, thus creating shadowing effects , but also impose spectral contaminations due to the continuous blade rotation. Therefore in order to identify, detect and possibly mitigate the presence of Wind Turbine Clutter (WTC) , fundamental features of the blades rotation need to be estimated, such as rotational (angular) velocity. This information can be easily extracted by initially evaluating the angle displacement of the blades between successive radar measurements. In this paper, a method to estimate this rotation angle is proposed which is based on both radar polarimetry and estimation theory.

17:10 ***Fast Ray-Optical Simulation of Rotating Wind Turbines***

Stefan Wald (Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Germany); Frank Weinmann (Fraunhofer FHR, Germany)

A fast ray-optical approach for electromagnetic simulation of rotating wind turbines is presented in this paper. The simulation results are well-suited for further data processing, e.g., generation of ISAR images or spectrograms, which implies a very large number of simulations to be performed. The algorithm works with detailed 3D CAD models of wind turbines and can process thousands of time steps within considerable computation time. The paper also provides a discussion of simulation requirements as well as a brief overview of alternative simulation methods.

17:30 ***Wind Turbines and Their Impact on Navigation Systems - Results of the min-VOR-Win Project***

Robert Geise, Björn Neubauer and Georg Zimmer (Technische Universität Braunschweig, Germany); Alexander Weiss (University of Braunschweig, Germany)

This contribution summarizes the results of a research project that investigated possible disturbances of the very high frequency omnidirectional radio range by multipath propagation with wind turbines. Such multipath propagation issues are analyzed in a miniaturized environment in the scale of 1:144 where the operating frequency of the navigation systems is translated to 16 GHz. A variety of measurements are performed under well-controlled parameter variations which cannot be realized in original scale environments. Such parameters are wing geometry, distance between wind turbines and the navigation system, rotational speed, and wing orientation. Additionally, flight test in real scale environments are performed as hypothesis test for predictions based on results in the scaled measurement environment. Another particular focus of this work is the development and the application of real receiver models that take into account both dynamic scatterers and a plurality of scatterers.

17:50 ***Radar Cross-Section of a Wind Turbine Application to Weather Radars***

Thomas Lepetit, Jérôme Simon, Jean-François Petex, Anil Cheraly and Jean-Paul Marcellin (ONERA, France)

We report RCS measurements of wind turbines in the C-band for both HH and VV polarizations. These show a common scattering mechanism between the two polarizations albeit with a large difference in amplitude. These results have a strong implication for polarimetric metrics used in weather radar algorithms. We thus highlight the need for dual-polarization radars or fine-grained simulations to properly assess the impact of wind turbines on weather forecast.

18:10 ***A Dynamic VOR Receiver Model for Estimating the Bearing Error in the Presence of Wind Turbines***

Seif Ben-Hassine, Alexandre Chabory, Christophe Morlaas and Remi Douvenot (ENAC, France)

This work introduces a dynamic VOR receiver model for estimating the bearing error in the presence of wind turbines. The receiver processes time series generated by an electromagnetic simulation tool that takes into account the multipaths. This global model can reproduce the response of a VOR receiver on a realistic aircraft trajectory. The receiver is tested in a dynamic scenario where the multipaths change rapidly with time.

H_A06 MM and THz: H_A06 Millimeter, sub-millimeter and TeraHertz antennas

TOP

High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Ali Farahbakhsh (Graduate University of Advanced Technology, Iran), Mohammad S. Sharawi (Polytechnique Montreal, Canada)

16:50 ***Energy Pattern Beamwidth of Linear Antenna Excited by Asymmetric Exponential Pulse***

Liubov Liubina, Mikhail Sugak and Victor Ushakov (Saint Petersburg Electrotechnical University LETI, Russia)

In this paper, analysis of energy pattern beamwidth for linear antenna excited synchronously by asymmetric exponential pulse is presented. Estimates, those are based on approximate relations, are derived and discussed. It is shown that relationships between dimensions of radiating surface, pulse spatial duration and energy pattern beamwidth for different types of exciting signals are in fact uncertainty relations. Expressions obtained allow to evaluate the energy pattern beamwidth of linear antenna excited synchronously by asymmetric exponential pulse, symmetric exponential pulse and step signal with finite duration of leading edge promptly. The formulas obtained with respect to the numerical solution give the errors in the 1.4-10% range.

17:10 ***3-D Printed Terahertz Lens with Circularly Polarized Focused near Field***

Gengbo Wu (City University of Hong Kong, Hong Kong); Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China); Chi Hou Chan (City University of Hong Kong, Hong Kong); Ka Fai Chan (State Key Laboratory of Terahertz and Millimeter Waves, Hong Kong); Yuan-Song Zeng (University of Electronic Science and Technology of China, P.R. China)

A novel 3-dimensional (3-D) printed near-field-focused (NFF) lens antenna operating at 300GHz is introduced in this paper. A linearly polarized (LP) feed horn is used to feed the lens. The designed lens can transform the LP incident waves into transmitted circularly polarized (CP) waves and concentrate them into a small spot simultaneously. Moreover, 3-D printing technique is used to simplify the manufacturing process at low cost. Measured results are provided to demonstrate the feasibility of the near-field CP focusing capability of the designed 3-D printed terahertz lens.

17:30 ***A Dual Circular-Polarized Antenna for mmWave Wireless Communications***

Chao Shu (Queen Mary University of London, United Kingdom (Great Britain)); Junbo Wang (Beijing University of Posts and Telecommunications, P.R. China); Shaoqing Hu (Queen Mary University of London, United Kingdom (Great Britain)); Junxiao Shen (University of Cambridge, United Kingdom (Great Britain)); Yuan Yao (Beijing University of Posts and Telecommunications, P.R. China); Xiaodong Chen (Queen Mary University of London, United Kingdom (Great Britain))

This paper presents our study on an antenna with dual circular polarization operating in W-Band. The antenna is capable of transmitting and receiving two orthogonal circular polarized signals (Left Hand Circular Polarization and Right Hand Circular Polarization) simultaneously to achieve Full-Duplex hence twofold spectrum efficiency in mmWave wireless communication systems. It mainly consists of a stepped septum polarizer and a profiled smooth-wall horn. The fabricated antenna shows 21% relative bandwidth from 76.8 GHz to 95 GHz with AR < 1.9 dB, the return loss is better than 15 dB and isolation > 20 dB for both LHCP and RHCP. It is also quite suitable to be used as a feed for a reflector antenna when high gain is also required besides high spectrum efficiency.

17:50 ***D-Band Slot Array Antenna Using Combined Ridge and Groove Gap Waveguide Feeding Network***

Ali Farahbakhsh (Graduate University of Advanced Technology, Iran); Davoud Zarifi (University of Kashan, Iran); Ashraf Uz Zaman (Chalmers University of Technology, Sweden)

In this paper, the design of a cavity-backed slot array antenna based on combination of ridge and groove gap waveguide for D-band applications is investigated. The proposed subarray has 2×2 slots with impedance bandwidth of 20 % covering from 127 GHz to 155 GHz. A feeding network combining groove gap waveguide and ridge gap waveguide has been proposed also in this work. The feed network has been designed as a combination of ridge gap waveguide and E-plane groove gap waveguide to reduce the losses in the feed network of a large antenna array, thereby increasing the total efficiency of the array antenna.

18:10 ***A 1-Bit, Low-Complexity, 20×20-Element Electronically Reconfigurable Reflectarray Antenna***

Yichen Zhong, Hung Luyen and Nader Behdad (University of Wisconsin-Madison, USA)

This paper presents an electronically reconfigurable reflectarray antenna with 1-bit phase correction. A low-complexity phase-shifting element with four patches and only one PIN diode is proposed to provide two electronically switchable states with a 180° phase difference. The reconfigurable reflectarray having a 300 mm × 300 mm aperture and a feed horn antenna were modeled and simulated in ANSYS HFSS. Full-wave simulated results show a good beam scanning performance from 8.7 GHz to 10.1 GHz over the scan range of ±45°. The simulated maximum gain and aperture efficiency are 23.5 dBi and 18%, respectively, at 10.1 GHz.

W_A03 Array Ant: W_A03 Array antennas, antenna systems and architectures

TOP

Wireless Networks and Defense and Security / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Francois Gallée (Télécom Bretagne, France), Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy)

16:50 ***A Radial Line Slot Array Antenna with Improved Radiation Patterns for Satellite Communication***

Mst Nishat Yasmin Koli, Muhammad Usman Afzal and Karu Esselle (Macquarie University, Australia); Md Zahidul Islam (Teleaus: Serveno Australia Pty Ltd, Australia)

In this paper we have investigated aperture field distribution of a radial line slot array (RLSA) antenna to improve the radiation pattern quality. A circularly polarised (CP) RLSA antenna was designed with tapered amplitude distribution. The distribution was obtained by manipulating the slot lengths on the antenna aperture based on a slot coupling analysis. The antenna has achieved a peak directivity of 31.7dBic and a peak gain of 31.3 dBic at 19.3 GHz. A significant improvement has been achieved in reducing side lobe levels. The antenna has demonstrated a side lobe level of -28.8 dB in ϕ = 0◦plane and -32.2 dB in ϕ = 90◦ plane at 19.3 GHz.

17:10 ***A Single-Layer Rectangular Patch Etched with Inverted L-Shaped Slots for Broadband Reflectarrays***

Lu Guo, Huiting Yu and Wenquan Che (Nanjing University of Science and Technology, P.R. China); Wanchen Yang (South China University of Technology, P.R. China)

This paper presents a broadband reflectarray antenna using single-layer rectangular patches loaded with a pair of inverted L-shaped slots. The rectangular patches have the same dimensions for all elements of the reflectarray and the phase shift is realized by tuning the length of the slots embedded within the patches. Consequently, the abrupt geometry variations for surrounding cells in conventional reflectarrays can be circumvented. The measured results indicate the proposed reflectarray can achieve a broad 1-dB gain bandwidth of 23% with aperture efficiency of 67% at 10 GHz.

17:30 ***Circularly Polarized Parallel Plate Waveguide Multiple-Beam Lens-like Antenna for Satcom Applications***

Nicola Bartolomei (University of Rennes 1, France); María García-Vigueras (IETR-INSA Rennes, France); François Doucet (IETR - University of Rennes 1, France); Darwin Blanco (Delft University of Technology, The Netherlands); Etienne Girard (Thales Alenia Space, France); Ronan Sauleau (University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

This paper describes a continuous parallel plate waveguide (PPW) quasi-optical beamformer (QOBF) with an array of septum polarizers to generate circular polarization. The PPW quasi-optical beamformer provides broadband and large scanning capabilities, although maintaining a relatively simple mechanical design. The septum polarizer is based on a stepped profile and is designed to provide circular polarization with axial ratio (AR) below 3 dB for a scan range of about ±19° in Ka-band (27.5 - 30.0 GHz).

17:50 ***Broadbeam Microstrip Patch Antenna Using Higher Order Modes***

Ismael Vico Trivino and Anja K. Skrivervik (EPFL, Switzerland)

The aim of this contribution is to assess the potential of using various microstrip radiating elements excited with different modes to achieve wide pattern beamwidths. The proposed antenna is made in classic microstrip technology and consists of a circular disk and a ring. The two radiating elements are excited for the TM10 and TM31 modes, respectively. Only the disk is fed, and the ring is connected to the disk through a microstrip line. The proposed antenna is matched at the 2.4GHz industrial, scientific and medical band (ISM) and exhibits a bandwidth of 120MHz. The combination of the two radiating elements achieves a 3dB beamwidth of 160 degrees. The maximum gain is 5.7dBi.

18:10 ***Distributed Antenna Array for FANET's Wireless Links Using Time Modulation***

Alberto Reyna (Autonomous University of Tamaulipas, Mexico); Marco Panduro (CICESE Research Center, Mexico); Aldo Mendez (Autonomous University of Tamaulipas, Mexico); Luz Idalia Balderas (Universidad Autonoma de Tamaulipas, Mexico); Carlos Del-Río (Universidad Publica de Navarra & Institute of Smart Cities, Spain)

This article presents a design of a distributed antenna array with time modulation for FANET's. The array is composed by nine dipole antennas. Each dipole element is mounted in single small aircraft. The design considers the optimization of time modulation sequences for low side lobes, maximum beamforming efficiency and low sidebands. The design process is carried out by using particle swarm optimization. The results reveled the feasibility of using time modulation in distributed antenna arrays for FANET's.

B_A01 Wear Implant: B_A01 Wearable and Implantable Antennas

TOP

Biomedical / Regular Session / Antennas

Room: Oral Sessions: A2- Ustka

Chairs: Marco A. Antoniades (University of Cyprus, Cyprus), Stavros Koulouridis (University of Patras, Greece)

16:50 ***SAR Evaluation for Implanted Multi-Node RF Wireless Leadless Cardiac Pacemaker Applications***

Qiong Wang (Dresden University of Technology, Germany)

Specific absorption rate (SAR) for the innovative implanted wireless leadless cardiac pacemaker (LCP) communications using RF frequencies is of significance to ensure the human safety particularly in the very important organ-human heart. Magnetic and electric small antennas behave differently in the near zone where magnetic type antenna is capable to provide a lower electric field

and produce a lower peak SAR meanwhile with a higher radiated power for implanted LCP application. Peak SAR with implanted exposure at higher frequency is higher than that at lower frequency, while higher frequency results in a faster SAR attenuation around the localized SAR peak due to larger attenuation exponential of the electric field. Multiple exposure mode will influence the SAR differently depending on the same/different exposure frequencies. In overall, the SAR peaks comply with the ICNIRP safety guideline and the transmitting power is supposed to be designed properly when multi-node RF implanted communication is covered.

17:10 ***Wireless Capsule Endoscopy Using Backscatter Communication***

Ali Khaleghi (Norwegian University of Science and Technology (NTNU) & Oslo University Hospital, Norway); Ilangko Balasingham (NTNU, Norway)

A small and efficient antenna is designed and manufactured for operating inside the human intestine. The antenna is used for radio frequency (RF) backscatter communication in which the antenna radar cross section (RCS) is altered using an active micro-watt switch. The switching mechanism modulates the incident wave transmitted from an external reader system, and the capsule data is transferred to the reader. Thus the active transmitter is removed from the implant and several 10s of mW power is saved. The power saving can realize real-time, and high data rate video streaming for improved visualization of the gastrointestinal tract. The implanted antenna is a conformal meander line with capacitive feed mechanism and provides dual-polar radiation to compensate for the capsule orientations in the gastric tract. The antenna design considers the specific environment of the biological tissues and provides a self-resonant geometry for high reflectivity. Bi-static backscatter method is used for the on-body reader antennas in the UHF band. The backscatter communication feasibility is demonstrated using numerical computations and experimentally validated in a liquid phantom and in-vivo animal experiments.

17:30 ***A Dual-Band Miniaturized Circular Antenna for Deep in Body Biomedical Wireless Applications***

Shuoliang Ding (GeePs & CentraleSupelec, France); Stavros Koulouridis (University of Patras, Greece); Lionel Pichon (Group of Electrical Engineering Paris, Universite Paris-Saclay, France)

In this paper, a novel miniaturized implantable circular PIFA antenna is presented. It supports both wireless information communication and wireless energy transmission at the Medical Device Radiocommunication band (MedRadio 402-405MHz) and the Industrial, Scientific and Medical bands (ISM 902.8-928 MHz). Antenna is circular to avoid sharp edges while miniaturization is achieved by adding two circular slots to the patch. Main scenario includes embedding into the muscle layer of a cylindrical three-layer model of a human arm for which several parameters are analyzed (resonance, radiation pattern and Special Absorption rate (SAR)). Power transmission efficiency and interaction distance limits to ensure connection are also evaluated.

17:50 ***Exploratory Study of In-body Communication Between Wearable Device and Multiple Implants and QPSK Digital Signal Transmission in Time-Domain***

Joao Felicio (Instituto de Telecomunicações, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal)

Implantable medical devices (IMDs) will be a crucial part in future health care systems. In fact, IMDs are expected be integrated in the next wireless system generation, 5G. This paper studies the in-body communication link between a low profile wearable antenna and an implantable antenna. We assemble a time-domain setup, in order to study the link by transmitting a quadrature-phase shift keying (QPSK) signal. This is an important analysis in order to fully assess the performance and feasibility of such link. The error vector magnitude of the received symbols shows Normal distribution, as predicted by theory for white Gaussian noise channels. Additionally, we evaluate the communication between the same wearable device and two implants at the same time. The results suggest such link is feasible although with relative position limitations. In fact, further research is needed to maximize power transfer to the gateway and minimize the energy coupling between implants.

18:10 ***Feasibility Study of PDMS Embedded Transparent Conductive Fabric for the Realization of Transparent Flexible Antennas***

Abu Sadat Md. Sayem, Roy B. V. B. Simorangkir and Karu Esselle (Macquarie University, Australia); Raheel Maqsood Hashmi (Macquarie University & IEEE, Australia)

In this paper the suitability and effectiveness of transparent conductive fabric for design and realization of transparent wearable antennas is studied. In contrast to the other expensive and non-flexible transparent conducting materials, transparent conductive fabric is an effective alternative for the realization of flexible transparent antennas. When embedded in polydimethylsiloxane (PDMS) this fabric becomes mechanically robust against repeated bending which is a requirement for many wearable devices. The performance of the transparent conductive fabric embedded in PDMS is evaluated for the wearable antenna application by fabricating a simple patch antenna operating at 2.45 GHz and testing its performance. The antenna prototype has been fabricated by using transparent conductive fabric VeilShield to form the conducting parts including the radiating element and PDMS as the substrate and encapsulation. Experimental investigations of the antenna demonstrate the applicability of the proposed material for the realization of transparent wearable antenna through a simple and inexpensive fabrication process.

Wednesday, April 3

Wednesday, April 3 8:40 - 12:30

CS40 Characteristic Modes: CS40 Progress in the Application of Characteristic Mode Analysis

TOP

Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Danie Ludick (Stellenbosch University, South Africa), Werner L. Schroeder (RheinMain University of Applied Sciences, Germany)

8:40 ***On the Size Reduction of Slotted Finite Ground Plane of a Circularly Polarized Microstrip Patch Antenna Using Substructure Characteristic Modes***

Arka Bhattacharyya and Bhaskar Gupta (Jadavpur University, India)

In this work, a miniaturized circularly polarized microstrip patch antenna with a slotted ground plane is designed by using substructure based theory of characteristic modes. The overall size of the antenna is miniaturized by systematically reducing the size of its ground plane. Circularly polarized nature of the antenna is achieved by properly shaping the slotted ground plane and the patch as well. The resonance behavior of the slotted ground plane is determined by its size as well as the shape of the patch. This phenomenon helps in achieving the size reduction of the ground plane by modifying the dimensions of embedded ground slots and controlling the size of the patch. It is found that substructure modal resonances can be positioned at desired frequencies by adjusting the size of ground slots and the patch even if a strong coupling exists between them.

9:00 ***Multi-Mode Antenna Concept Based on Symmetry Analysis of Characteristic Modes***

Nikolai Peitzmeier (Leibniz University Hannover, Germany); Dirk Manteuffel (University of Hannover, Germany)

A multi-mode antenna concept based on a symmetry analysis of characteristic modes is presented for use in massive MIMO antenna arrays. A hexagonal plate is chosen as the basis of the antenna concept due to its interesting geometric properties. In particular, a symmetry analysis using group theory and representation theory is conducted in conjunction with a characteristic mode analysis, yielding that a hexagonal plate offers eight mutually orthogonal sets of characteristic surface current densities. On this basis, eight uncorrelated antenna ports are defined by means of the irreducible representations of the symmetry group.

9:20 ***LTE Antenna Design for Tablet Computers Using Characteristic Mode Analysis***

Peter William Futter (Altair Development S.A. (Pty) Ltd, South Africa); Ulrich Jakobus (Altair Engineering GmbH, Germany)

This paper highlights the advantages of using a characteristic mode analysis based approach to design a wideband tablet computer antenna that operates in the LTE low band. Insight into the modal behavior is used to optimize the antenna geometry and positioning to excite modes on the tablet ground plane. Each design decision is motivated by the impact on the modes, which is explained for each step in the design process. Compared to the initial design, significant improvements are achieved in the final antenna performance following this approach.

9:40 ***Applying the Theory of Characteristic Modes to the Analysis of Finite Antenna Array Elements and Ground Planes of Finite Sizes***

Danie Ludick (Stellenbosch University, South Africa)

This paper presents the characteristic mode analysis (CMA) of finite antenna array elements embedded in an array environment. The approach introduced here also incorporates the effect of a finite-sized ground plane. Two method-of-moments domain decomposition strategies are combined in this CMA enhancement, viz., the Domain Green's Function Method, as well as the Numerical Green's Function technique. The combination of these methods allows us to extract a modified impedance matrix for each of the array elements, which incorporates the mutual coupling effects from the array environment - as well as that caused by the ground plane. Characteristic mode analysis can then be applied to this altered self-interaction matrix to calculate the modified eigencurrents and eigenvalues associated with an element embedded in the array environment. The solution approach also lends itself to the analysis of both regular and irregular array geometries with disconnected and identical elements.

10:00 ***Compact UHF Antenna Utilizing CubeSat's Characteristic Modes***

Adam Narbudowicz (Wroclaw University of Science and Technology, Poland & TU Dublin, Ireland); Suramate Chalermwisutkul (King Mongkut's University of Technology North Bangkok & The Sirindhorn International Thai-German Graduate School of Engineering, Thailand); Ping Jack Soh (Universiti Malaysia Perlis (UniMAP) & Katholieke Universiteit Leuven, Malaysia); Faizal Jamlos (Universiti Malaysia Perlis, Malaysia); Max James Ammann (Dublin Institute of Technology, Ireland)

The paper investigates the use of CubeSat body as an UHF antenna for 435 MHz band. Since the lowest characteristic modes in 1U CubeSat become significant around 1 GHz, a set of four arms is developed to decrease this frequency and realize compact antenna that can be enclosed within in a sphere of 0.3 wavelength diameter. The antenna does not rely on any deployment mechanism, significantly increasing reliability of the satellite. Two use-cases are investigated: a linearly polarized with omnidirectional pattern and a bi-directional circularly polarized. Both offer broad beams with 1.6 dB gains, which is comparable to much larger deployable CubeSat antennas.

10:20 Coffee Break

10:50 ***A Novel Method to Interpret the Mutual Coupling Based on Characteristic Mode Theory***

Wei Su (Queen Mary, University of London, United Kingdom (Great Britain)); Qianyun Zhang and Yue Gao (Queen Mary University of London, United Kingdom (Great Britain))

This paper presents a novel method to evaluate the mutual coupling based on the theory of characteristic mode (TCM). The radiation energy and mutual coupling of each port in an antenna system is decomposed. The modal contribution on both radiation energy and mutual coupling are unified and represented by the same term, i.e., the modal energy occupied coefficients (MEOC). In addition to this, the linear transformation of feeding network in the multi-port antenna system has been adopted to complete the modal based method. A four-port rectangular antenna and a twin dipole system are used as examples to verify the method.

11:10 ***Characteristic Mode Analysis of User's Effect on Mobile Handset Antennas***

Pasi Ylä-Oijala, Anu Lehtovuori and Rasmus Luomaniemi (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

Theory of characteristic modes is presented for structures with coexisting PEC and lossy dielectric parts. The developed method allows analysis of the radiation properties of the modes and their lossy mechanism. The usefulness of the method for practical antenna design tasks is demonstrated by investigating modes on a PEC plate (antenna ground plane) and an adjacent lossy dielectric structure (user's hand).

11:30 ***Coupling Analysis of Metamaterial Inspired Structures Using the Theory of Characteristic Modes***

Ozuem Chukwuka (University of Lille & IFSTTAR Institute, France); Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France); M. Hassanein Rabah (IFSTTAR & University Lille 1 Nord de France, France)

Metamaterial inspired designs have been explained with the principle of compensation of stored energy between the antenna and the metamaterial. This compensation can be attributed to the coupling between the metamaterial and the antenna. In this paper, we use the theory of characteristic modes in analyzing the coupling between a metamaterial inspired design and its excitation as well as the coupling between the different modes of a metamaterial inspired design. The result obtained validates and gives more insight into the compensation of stored energy explanation for metamaterial inspired design.

11:50 ***Broadband Hexagonal Antenna Based on Metasurface Using Characteristic Mode Analysis***

Wenzhang Zhang, Chaoyun Song, Yuan Zhuang, Qiang Hua, Yi Huang and Jiafeng Zhou (University of Liverpool, United Kingdom (Great Britain))

A novel low-profile broadband hexagonal antenna based on metasurface using characteristic mode analysis (CMA) is presented. By properly cutting slots on the radiating elements, an array of capacitively loaded hexagonal patches and polygon-shaped parasitic elements is formed. The antenna is excited through a feeding slot on the ground plane. By introducing a slot on the central radiating element, an improved impedance matching and relatively stable radiation patterns over a wide band are achieved. In addition, a mode can be excited on the parasitic elements simultaneously to widen the frequency bandwidth. The CMA is employed for modeling, analyzing, and optimizing the proposed antenna in order to reveal the underlying modal behaviors. The proposed hexagonal antenna has a low profile with an overall size of 0.86λ0 × 0.86λ0 × 0.08λ0. It has realized a fractional bandwidth of 54% and an average gain of 6.5-10 dBi.

12:10 ***Characteristic Mode Analysis of a Circular Polarised Rectangular Patch Antenna***

Jan E. Bauer and Philipp Gentner (KATHREIN SE Germany)

This paper discusses the analysis of a circular polarised patch antenna with the theory of characteristic modes. The objective is to find a feeding position and achieve the purest possible form of a polarised farfield pattern. By using characteristic mode analysis (CMA) the best case pattern supported by the structure can be extracted. Therefore the most important modes for circular polarisation are isolated and used for mode combination. The resulting pattern is used as a reference for envelope correlation coefficient (ECC) with the second pattern provided by regular field solver. By changing the feed type and or position different results can be characterised in their polarisation purity and therefore axial ratio.

CS47 ESA Multibeam and Reconf Ant: CS47 ESA session: Selected papers from the 39th ESA Workshop on Multibeam and Reconfigurable Antennas

TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Piero Angeletti (European Space Agency, The Netherlands), Giovanni Toso (European Space Agency, The Netherlands)

8:40 ***24 GHz Additive Manufactured Antenna in Mixed Material Technology***

Cristina Yepes (Delft University of Technology, The Netherlands); Erio Gandini (TNO, The Netherlands); Stefania Monni, Raymond van Dijk and Frank van Vliet (TNO Defence Security and Safety, The Netherlands); Hessel Maalderink (AMSYSTEMS Center/TNO, The Netherlands)

A 24 GHz antenna in additive manufacturing technology for miniaturized FMCW radar is presented. The characterization of the polymer material used in the fabrication was carried out and the measurement results of the antenna are presented in this work. A good agreement between simulations and measurements was achieved.

9:00 ***Additive Manufacturing of K/Ka/Q/V-Band Feed-Horns***

Giuseppe Addamo (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT-CNR), Italy); Oscar A. Peverini (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT- CNR), Italy); Fabio Paonessa (National Research Council of Italy (CNR - IEIIT), Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Flaviana Calignano (Dipartimento di Ingegneria Gestionale e della Produzione, Politecnico di Torino, Italy); Diego Manfredi (IIT, Italy)

In this work the design and the Selective Laser Melting (SLM) manufacturing of single- and dual-band high-performance horns operating within the Ku to V bands are considered. A smooth wall architecture has been preferred in order to simplify the manufacturing and enhancing the SLM quality. Three prototypes have been designed, built and successfully tested

9:20 ***Multiple Spot Beam Reflector Antenna for High Throughput Satellites Using Additive Manufacturing Technology***

Alexander Sommer and Andreas Schinagl-Weiß (Airbus Defence and Space GmbH, Germany); Christian Hartwanger (Airbus, Germany); Michael Kilian (Airbus Defence and Space GmbH, Germany); Michael Schneider (Airbus, Germany)

This paper presents a multiple spot single-feed-per-beam antenna for high throughput satellites. A three reflector solution is employed that uses horns, specially designed to maximize not only the directivity but also the carrier-to-interference ratio. In order to save costs for assembly and integration, an entire feed cluster including waveguide routing was manufactured by additive manufacturing technology. The determined performance for a multiple spot beam Ku-band scenario, based on measured pattern of the manufactured feed cluster, demonstrates the efficiency of the approach.

9:40 ***Design and Qualification of Ku-Band Radiating Chains for Receive Active Array Antenna of Flexible Telecommunication Satellites***

Vincenzo Pascale, Davide Maiarelli and Luciano D' Agristina (Space Engineering S.p.A., Italy); Nicola Gatti (Space Engineering, Italy)

Space Engineering recently developed enhanced passive components as key elements for its telecom Ku-band antenna product line, tailored to reconfigurable payloads. This paper describes the design and qualification of a dual linear polarization Ku-Band radiating chain, developed for the DRA receive (Rx) antenna embarked on the Eutelsat Quantum satellite. The feed chain covers the entire Ku-band frequency range allocated for Fixed Satellite Services (FSS) providing receive functionality and embedding sharp rejection features over the adjacent transmit band. Details of the feed chain design and an overview of RF and environmental qualification test results are presented.

10:00 ***Mesh Based Reflector Surfaces***

Maurizio Lori (HPS GmbH, Germany); Thomas Sinn (HPS-GmbH, Germany); Ernst Pfeiffer (HPS GmbH, Germany); Davide Smacchia (ESA/VSC High Power RF Laboratory, Spain); Jean Christophe Angevain (ESA ESTEC, The Netherlands)

HPS has been since several years active in the field of RF reflective meshes by making use of German companies which are expert in the production of such type of materials but also involving directly companies producing the knitting machines. This permits to realize the best materials which are obtainable with the current technologies. Scope of this paper is to present the results and performances (RF) obtained with the developed mesh technologies.

10:20 Coffee Break

10:50 ***Active Antenna Technologies for SAR Based on Digital Beam-forming***

Grzegorz Adamiuk (Airbus Defence and Space GmbH, Germany); Michael Ludwig (ESA/ESTEC, The Netherlands)

Digital Beam Forming (DBF) is a key technology for future space-borne SAR systems. It allows e.g. for realization of imaging products with high resolution and significantly higher swath widths, when compared to SAR system based on classical phased array technology. Such technique is called High Resolution Wide Swath (HRWS) and allows for increase of mission efficiency in terms of coverage/resolution by factors (e.g. 5-8). This paper gives an overview of hardware developments at Airbus in Friedrichshafen aiming at future DBF based SAR systems in C- and X-band.

11:10 ***Latest Achievements on Continuous Transverse Stub - Pillbox Antennas at IETR***

Thomas Potelon (IETR - University of Rennes 1, France); Francesco Foglia Manzillo (CEA-LETI, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Ronan Sauleau (University of Rennes 1, France)

This paper presents four innovative CTS-pillbox antenna prototypes recently designed at IETR. Beside the very attractive performance achieved by this architecture in terms of bandwidth and compactness, new capabilities are demonstrated such as high gain, reduced sidelobe level, radiation pattern reconfiguration in principal planes and active beam switching with a high beam overlapping level. Moreover, new fabrication technologies have been investigated: printed circuit board (PCB)-air hybrid technology, full PCB technology, and low-temperature co-fired ceramic (LTCC) technology. All concepts are validated by experimental results. These works constitute a substantial advancement for CTS-pillbox antennas for current and future millimeter-wave

applications.

11:30 ***In Orbit Test Verification Results for the ELSA Antenna on Board Hispasat AG1 Satellite***

Jose Ignacio Echeveste (Airbus Defence and Space, Spain); Eduardo González (Former Airbus, Spain); Agustín Zornoza (Hispasat, Spain); Arturo Martin Polegre (European Space Agency, The Netherlands); Eric Villette (ESA, Spain); Silvia Arenas (EADS-CASA Espacio, Spain); David Peña and Miguel Bustamante (EADS CASA Espacio, Spain); Luis de la Fuente and Antonio Montesano (EADS-CASA Espacio, Spain)

The ELectronically Steerable Antenna (ELSA) is a multibeam active antenna working in reception. It is accommodated on the HISPASAT AG1 satellite as part of the REDSAT payload working in the Ku-band. The antenna is able to point and reshape any of its four beams in every possible direction on Earth seen from its geostationary orbit. The In-Orbit Test (IOT) shall demonstrate that no degradation has occurred during launch of the satellite and that the inflight performance fit the requirements. The main goal of IOT is not to provide a complete characterization of the antenna; this has already been done on ground exhaustively and with better measurement accuracy. However, it is required to assure that a representative set of performance parameters has remained unchanged from ground tests. Of course, this comparison is restricted due to the reproducibility of measurements, especially due to the reduced measurement accuracy in orbit.

11:50 ***Single and Dual Reflectarray Configurations for Multibeam Satellite Antennas in Ka-Band***

Daniel Martinez-de-Rioja (Universidad Politécnica de Madrid, Spain); Eduardo Martinez-de-Rioja and Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Antonio Pino, Yolanda Rodriguez-Vaqueiro, Borja Gonzalez-Valdes, Oscar Rubiños-López and Marcos Arias (University of Vigo, Spain)

This contribution proposes the use of single and dual reflectarray configurations to provide multi-spot coverage in Ka-band from a geostationary satellite, using a smaller number of apertures and feeds than conventional reflector systems. First, a 1.8-m parabolic reflectarray antenna has been designed to produce multiple spot beams through the generation of two beams per feed in orthogonal circular polarization (CP) at Tx and Rx frequencies. Moreover, a dual RA configuration has been designed to produce two spot beams in orthogonal CP from a single feed in dual linear polarization (LP). The simulated results are compared for the two designed antennas, showing the feasibility of both configurations and their potential to be used for multiple beam applications in Ka-band.

12:10 ***Design Tool for End-to-End Optimisation of High-Performance Multibeam Antenna Systems***

Erik Jørgensen, Niels Vesterdal, Min Zhou, Peter Meincke, Oscar Borries, Michael F. Palvig, Tonny Rubæk and Cecilia Cappellin (TICRA, Denmark)

This paper describes a new integrated RF design tool for analysis and end-to-end optimisation of reflector-based multibeam antenna systems consisting of passive microwave components, feed horns, reflectors, as well as reflectarrays, transmitarrays, or frequency and polarisation selective surfaces. The term end-to-end is used to indicate that the entire multibeam system can be optimised as one model, with goals directly on the final performance of the complete antenna system, e.g., the return loss at the input ports of the first feed chain component and the antenna beam after the last reflecting surface. We illustrate the new capabilities with two design examples.

Wednesday, April 3 8:40 - 10:20

CS2 mmWave Mob App: CS2 mmWave for Mobile Applications

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Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Michael Jensen (Brigham Young University, USA), Janet O'Neil (ETS-Lindgren, USA)

8:40 ***LTCC Based Dual-Polarized Magneto-Electric Dipole Antenna for 5G Millimeter Wave Application***

Shaobo Chen and Anping Zhao (Shenzhen Sunway Communication Co., Ltd, P.R. China)

A dual-polarized millimeter wave antenna for 5G application is proposed in this paper. Magneto-electric dipole antenna concept is utilized for this design. Due to the high dielectric constant ceramic material used by LTCC process, the size of the antenna is small which is helpful for integration of the antenna into some home held devices, such as femtocell, Customer-Premises Equipment (CPE), etc. The common operating frequency range of the antenna is from 26.39 GHz to 28.64 GHz that is sufficient for the FCC regulated frequency band. The boresight gain of the antenna for both polarizations is above 5.5 dB across the working frequency range. And the corresponding radiation efficiency is on the level of 90%. The isolation of the dual-polarized antenna is lower than -36 dB. With the help of the LTCC fabrication technology, this antenna is suitable for 5G millimeter wave applications by integrating into the antenna module.

9:00 ***5G mmWave Beam Steering Antenna Development and Testing***

Carlo Bencivenni and Magnus Gustafsson (Gapwaves AB, Sweden); Abolfazl Haddadi (Gapwaves AB, Gothenburg, Sweden); Ashraf Uz Zaman (Chalmers University of Technology, Sweden); Thomas Emanuelsson (Gapwaves AB, Sweden)

mmWave frequencies offer unprecedented capacity but also new technical challenges. Current solutions typically adopt integrated PCB antennas, however they still face issues when it comes to coverage, power consumption and cost. Instead, we present a 5G mmWave antenna platform demonstrating a different approach based on Gapwaves technology. The proposed design is an integrated all-metal multi-layer assembly, offering low-loss feeding, high-gain subarray, high-Q filters and exceptional thermal handling. To support these claims, active measurement of beam steering, EIRP and temperature are presented. Results from this small demonstration unit are very encouraging and show performance challenging that of much larger systems.

9:20 ***Testing the 5G New Radio***

Michael D. Foegelle (ETS-Lindgren, USA)

Alongside the development and test deployment of 5G new radio technology, the wireless test and measurement industry is working to develop the required test and measurement capabilities to handle the necessary testing. Various industry organizations are working towards developing test plans and defining test requirements that will be implemented throughout the industry. This paper will review these efforts and their current progress.

9:40 ***Channel Characteristics for 5G Wireless Systems Operating in Millimeter-wave Bands***

Rashid Mehmood (Wavetronix LLC, USA); Michael Jensen (Brigham Young University, USA); Jon Wallace (Lafayette College, USA)

Co-located 4x4 multiple-input multiple-output measurements of link gain, delay spread, and capacity at 24 GHz and 2.55 GHz are compared for an indoor environment consisting of offices, large rooms, and hallways. The results show that link gain at the two frequencies is similar in hallways and connected laboratories after removing the impact of effective antenna aperture but is much lower at 24 GHz in non-line-of-sight scenarios. For all environments, median delay spreads as well as system capacity at a fixed signal-to-noise ratio at 24 GHz are similar to those observed at 2.55 GHz. Ray tracing simulation results show reasonable to good agreement with the measured link gain but tend to provide lower capacity estimates. Overall, the results suggest that bands near 24 GHz may be able to support multiple-antenna communication strategies.

10:00 ***Automotive mmWave Radar EMC Test Developments and Challenges***

Jianmei Lei (State Key Laboratory of Vehicle NVH and Safety Technology & Chongqing Engineering Research Center for Automotive EMC Development, P.R. China); Yang Xu (Chong Qing University, P.R. China)

Automotive mmWave radar has been widely used in Advanced Driving Aid Systems (ADAS), meanwhile, plays a more and more important role in the autonomous driving systems. With the increase number of inter-vehicle electronic systems and surrounding electromagnetic (EM) radiation, the EM environment inside and around the vehicle is growing more complicated. To ensure the effectiveness of mmWave radar system under complicated EM condition, corresponding Electromagnetic Compatibility (EMC) tests are needed. However, EMC test for mmWave radar performs some unique characteristics, which differ from that of traditional EMC test, and a new test scheme is needed to design to match the related specific demands. In this paper, the challenges of automotive mmWave radar EMC test are analyzes, while an in-lab Electromagnetic Susceptibility (EMS) test procedure for automotive mmWave radar systems is put forward. Experiments conducted in a 10-meter semi-anechoic chamber of China Automotive Engineering Research Institute Co., Ltd (CAERI) verifies the effectiveness of proposed procedure.

Wednesday, April 3 8:40 - 12:30

CS31 IET: New Antenna Systems CS31 IET session: New Antenna Systems involving Application of Metamaterials and Metasurfaces

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Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Kenneth Lee Ford (University of Sheffield, United Kingdom (Great Britain)), Hisamatsu Nakano (Hosei University, Japan)

8:40 ***Metalines with a Patch Antenna***

Hisamatsu Nakano, Tomoki Abe and Junji Yamauchi (Hosei University, Japan); Arpan Pal (Swansea University, United Kingdom (Great Britain)); Amit Mehta (Swanse University, United Kingdom (Great Britain))

An antenna system composed of metalines and a single patch is investigated for forming a null within the radiation beam. Both the metalines and patch are printed on a thin dielectric substrate backed by a conducting plane. The metalines are excited in phase to radiate a circularly polarized (CP) conical beam, whose magnitude and phase are almost constant around the vertical center axis of the antenna system. On the other hand, the radiated beam from the patch, which is also CP, has an almost constant magnitude around the vertical center axis of the antenna system, but has a 360-degree shift in the phase. It is found that the phase difference between the input excitation of the metalines and the input excitation of the patch controls the azimuth angle of a null within the radiation beam, while the power difference of the input excitations controls the elevation angle.

9:00 ***High-Aperture-Efficiency Fabry-Pérot Cavity Antenna Using Hybrid-Mode Metasurface***

Wei Liu, Zhi Ning Chen and Sweatha Devi Gandhi (National University of Singapore, Singapore)

A high-aperture-efficiency Fabry-Pérot (FP) cavity antenna using a hybrid-mode metasurface is proposed. A finite-size metasurface supports the FP cavity resonance and a TE surface wave resonance simultaneously. The combination of the two resonances results in the excitation a new hybrid mode, generating a more uniform field amplitude distribution. A directivity of 15.45 dBi and a high aperture efficiency of 94.36% are achieved. The prototype FP cavity antenna shows a good agreement between the measured and simulated results.

9:20 ***A Metasurface for Multi-nuclear Magnetic Resonance Imaging Applications at 1.5T***

Tingzhao Yang, Kenneth Lee Ford, Madhwesha Rao and James Wild (University of Sheffield, United Kingdom (Great Britain))

This paper will describe a novel method to achieve multi-nuclear imaging for 1.5T MRI systems using a combination of a surface coil and metasurface. An inter-digitated capacitive metasurface with a dual loop radio frequency (RF) transceiver coil is proposed to achieve dual band imaging for a single RF feed. Fluorine nuclei 19F and hydrogen nuclei 1H are focused of this study, whose resonant (Larmor) frequencies are 60.08MHz and 63.85MHz respectively when used in 1.5T MRI. Simulation results indicate the RF magnetic flux density, ,which is proportional to signal-to-noise-ratio (SNR), is increased by a maximum of 8% at 60.08MHz on 19F phantom surface, and 1100% at 63.85MHz on 1H phantom surface when compared to a single resonance RF surface transceiver coil.

9:40 ***Reconfigurable Reflective Metasurface for Dynamic Control of Focal Point Position***

Badreddine Ratni (Univ Paris Nanterre, France); Zhuochao Wang, Kuang Zhang and Xumin Ding (Harbin Institute of Technology, P.R. China); André de Lustrac (Institut d'Electronique Fondamentale - Université Paris-Sud, France); Shah Nawaz Burokur (LEME, France)

Spatial energy distribution is manipulated to control and focus an incident plane wave at any spatial position. For this purpose, an ultrathin reconfigurable reflective metasurface is designed through the use of unit cells incorporating voltage-controlled varactor diodes. The phase characteristic of each unit cell is individually controlled and allows to dynamically control the position of the focal point. Near-field measurements are performed on a fabricated prototype validating the concept.

10:00 ***Electrically Small, Highly Efficient, Huygens Circularly Polarized Rectenna for Wireless Power Transfer Applications***

Wei Lin (University of Technology Sydney, Australia); Richard Ziolkowski (University of Technology Sydney, Australia & University of Arizona, USA)

This paper introduces the first realized electrically small, highly efficient, Huygens circularly polarized (HCP) rectenna for wireless power transfer applications. It is designed to operate at the 915 MHz in the corresponding ISM band. It is realized through the seamless integration of an electrically small HCP antenna and a highly efficient rectifier circuit. The electrically small HCP antenna consists of four electrically small near-field resonant parasitic (NFRP) elements: two Egyptian axe dipoles (EADs) and two capacitively loaded loops (CLLs). The rectifier is a full-wave rectifying circuit based on HSMS286C diodes. It is integrated with the HCP antenna on its bottom layer. A HCP rectenna prototype was successfully fabricated and tested. It is electrically small (ka < 0.77). Excellent CP radiation absorption capacity is observed. The measured peak AC to DC conversion efficiency reaches 82%.

10:20 Coffee Break

10:50 ***Broadband Metasurface Antennas***

Marco Faenzi (Université de Rennes 1, France); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Stefano Maci (University of Siena, Italy)

Modulated metasurface (MTS) antennas typically present a low-profile, light weight, and simple feeding schemes, with the feeder embedded in the aperture plane. They are also easy to integrate in platforms. Despite this structural simplicity, modulated MTSs can provide both high-gain pencil beams and shaped beams with high polarization purity. These radiation characteristics are obtained owing to a surface-wave to leaky-wave transformation, which stems from the periodic modulating of an artificial reactance plane. Modulated MTSs are, however, subject to the inherent frequency dispersion of this artificial reactance plane. Dispersion leads to a progressive phase mismatch with respect to the periodicity of the modulation, and hinders the gain bandwidth of the antenna. Here, we deal with this limitation by appropriately tailoring the modulated impedance. Full-wave simulations show that the proposed structure features a very good pattern stability, a flat directivity versus frequency response, and good cross-polarization purity at Ka band.

11:10 ***A Novel Reconfigurable EBG Structure and Its Potential Use as Liquid Sensor***

Sungyun Jun and Benito Sanz-Izquierdo (University of Kent, United Kingdom (Great Britain)); Edward Parker (The University of Kent, United Kingdom (Great Britain))

A novel reconfigurable antenna using a modified electromagnetic band gap (EBG) structure is introduced. The EBG is made of an array of square patches with a series of cuts and grooves in the dielectric material between the patches. These grooves allow for the deposition of liquids that can be used to change the resonant frequency of the antenna. The variation in the dielectric permittivity of the liquids produces a change in the reflected phase of the EBG. This change in phase is detected using a planar antenna placed at a short distance from the EBG structure. The change in phase in the EBG produces a change in the reflection coefficient of the antenna. This relationship is shown to be linear for lossless liquids. The reconfigurable structure could also be used as a sensor or detector. In order to assess the use as a sensor, Butan-1-ol, propan-2-ol, ethanol and methanol have been tested. The reflection coefficients and the radiation patterns were measured. Simulations were carried out simulated and measured results.

11:30 ***Metasurface Reflector Antenna with Improved Bandwidth and Reduced RCS***

Henry Giddens (Queen Mary University London, United Kingdom (Great Britain)); Yujie Liu and Phillip Beal (Colleague, United Kingdom (Great Britain)); Yang Hao (Queen Mary University, United Kingdom (Great Britain))

Modern day computational techniques have introduced new methods for designing complex antenna and electromagnetic devices. Through computer simulations, antenna engineers are now able to optimize designs for various criteria by modifying specific parameters. In this paper, we demonstrate metasurfaces that are specifically engineered in order to enhance antenna properties for specific applications. Using a genetic algorithm based optimization approach to the metasurface design, a metasurface reflector is designed with the specific goal of increasing the bandwidth of a wide-band, printed dipole array. The resulting meta-surface is also able to significantly reduce the radar cross section (RCS) of the dipole array compared to the case when it is positioned above a PEC reflector, although a slight reduction in radiation efficiency is experienced. The metasurface is fabricated and the measurement results show good agreement to the simulations, achieving an 8dB reduction in the RCS at the centre frequency.

11:50 ***Design of A Metamaterial-Inspired Reflectarray to Increase the UHF-Band RFID Detection-Range***

Sungtek Kahng (University of Incheon, Korea); Gwang-Gyun Namgung, Changhyeong Lee and Heejun Park (Incheon National University, Korea); Aurora Andújar (Fractus, Spain); Jaume Anguera (Fractus Antennas & Universitat Ramon Llull, Spain)

In this paper, we present a way to increase the operational efficiency of the UHF-band RFID system. A Flat reflecting surface is placed behind a small UHF antenna and changes a low antenna gain to a high one. We set 920 MHz as the target frequency and obtain benefits of 6.5 dB-gain increment and relatively a small volume for wavelength of 32.6 cm. It is shown that both the source antenna and the metamaterial-inspired reflecting surface are planar, which makes the system easy to develop for a high gain and maintenance.

12:10 ***MetaSurface Structures for Sensing and Communications***

Luigi La Spada (Edinburgh Napier University, United Kingdom (Great Britain)); Anna Maria Vegni (Roma Tre University, Italy)

MetaSurfaces are used to fully control electromagnetic waves' propagation properties. Specifically, in this paper we present a unified approach, consisting in modeling, design and practical realization, to manufacture arbitrary curvilinear MetaSurfaces. We will validate the proposed technique by designing, realizing and testing a MetaSurface structure for sensing and telecommunications applications. Good results are obtained in terms of bandwidth, polarization independence and fabrication simplicity. Most importantly, the proposed approach appears to be versatile and scalable.

Wednesday, April 3 8:40 - 10:20

C_A07 Array Ant: C_A02 Array antennas, antenna systems and architectures

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-A - Poznan

Chairs: Stefan Lindenmeier (Universität der Bundeswehr, Germany), Stefania Monni (TNO Defence Security and Safety, The Netherlands)

8:40 ***Dual Polarized Travelling-Wave Array Antenna Formed by Printed Cross Slots***

Pablo Sanchez-Olivares and Jose Luis Masa-Campos (Universidad Autonoma de Madrid, Spain); Pradeep Kumar (University of Kwazulu-Natal, South Africa); Eduardo Garcia-Marin (Universidad Autonoma de Madrid, Spain)

A dual polarized travelling-wave array antenna in Ku-band is presented. The array design uses the two orthogonal modes TE10 and TE01 mode supported by a square waveguide feeding. Each single element of the array contains two orthogonal slots (transversal and longitudinal slots), forming a cross slot. Thus, transversal slots are excited by TE10 mode while longitudinal slots are excited by TE01 mode, generating the dual linear polarization. Likewise, a dual polarized array antenna fed by a square waveguide is designed for 98% of radiated power at the design frequency. In order to mitigate the grating lobe appearance as well as to minimize the reflected wave, the distance between elements has been optimized. Due to the proximity between slots, a printed version of the cross slot is proposed to reduce its resonant length. Therefore, mutual coupling effects are reduced, also preventing overlapping between adjacent slots. Finally, the dual polarized array antenna is manufactured and measured. A good agreement between simulated and measured results is achieved, also obtaining high efficiency for both linear orthogonal polarizations.

9:00 ***Microstrip Antenna Array with Grating Lobe Mitigation with Optimized Polarization***

Elizabeth Bekker, Johann W Odendaal and Johan Joubert (University of Pretoria, South Africa)

Many grating lobe mitigation methods to date use isotropic sources as array elements. This paper extends a grating lobe mitigation method that makes use of modular, convex pentagons as subarrays to completely cover an approximately circular, planar array, by using wideband, dual polarized microstrip elements. Through the use of the dual polarized elements, optimized polarization for an arbitrary polarization angle is achieved in the main beam direction, with a minimized crosspolarization component.

9:20 ***Performance of a 28 GHz Two-Stage Rotman Lens Beamformer for Millimeter Wave Cellular Systems***

Muhammad Ali Babar Abbasi (Queen's University Belfast & The Institute of Electronics, Communications and Information Technology (ECIT), United Kingdom (Great Britain)); Harsh Tataria (Lund University, Sweden); Vincent Fusco and Michail Matthaiou (Queen's University Belfast, United Kingdom (Great Britain))

Phase shifter--based hybrid beamforming has received a lot of attention at millimeter--wave frequencies for cellular communications. Nevertheless, the implementation complexity of such beamformers is rather high due to the complexities involved in designing and fabricating the required radio--frequency (RF) circuits. In contrast, lens-based RF beamformers significantly reduce the implementation complexity, as all active circuits can be replaced by a passive device. In this paper, we present the sum spectral efficiency performance of an uplink multiuser multiple-input multiple-output (MU--MIMO) system with a 28 GHz Rotman lens. An asymmetric two-stage stacked design is fabricated with a 15 element 3 x 5 uniform rectangular array feeding 9 RF down--conversion chains towards baseband. Zero-forcing processing is employed at baseband for interference nulling and multistream recovery. Our results show that the MU--MIMO gains are substantially more pronounced for the two--stage architecture relative to a single-stage design due to the inclusion of the elevation multipath components. Moreover, we show that the asymmetric design can help to further reduce the implementation complexity, since the conventional beam selection network can be omitted from the RF front--end.

9:40 ***A Low-Cost Analog Beamforming Antenna for 5G mm-Wave Handset Applications***

Marzieh SalarRahimi and Eduardo Anjos (KU Leuven, Belgium); Tom Buss (NXP Semiconductors, The Netherlands); Dominique Schreurs (KU Leuven, Belgium); Marcel Geurts (NXP Semiconductors, The Netherlands); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium)

A 2x2 active array module at 28 GHz is presented targeting 5G handset applications. The module was designed using a four-layer PCB stack and large-size vias to reduce overall manufacturing costs. Its implementation choices are described, and over-the-air measurements were performed to demonstrate its beam steering capabilities and maximum EIRP of +34.6 dBm was achieved at 26 GHz.

10:00 ***PSO-based Combined Antenna and Matching Network Optimization for Mobile Terminals***

Tran Quang Khai Nguyen (Université Cote d'Azur, CNRS, France); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Leonardo Lizzi (University Côte d'Azur, CNRS, LEAT, France)

In this paper, the challenge of antenna design for a full-screen smartphone will be analyzed and an optimization methodology is introduced. The Particle Swarm Optimization algorithm is used in combination with HFSS and Optenni commercial software in order to simultaneously optimize the antenna geometry and the matching network. Optimizing antenna and matching network separately, as conventionally done, does not guarantee the optimal performance. The proposed method is tested on a very space constraint model with a 5mmx5mmx73mm volume for the antenna and a 140mmx73mm ground plane. Within this space, an antenna solution covering the 700-960 MHz and 1690-2700 MHz bands with a minimal total efficiency higher than 50% has been obtained. This methodology has the potentials to enable an automatically and systematically design process for antenna-matching network systems.

c_A05 Arrays High DT: C_A05 Arrays for High Data Transfer

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden), Tao Huang (Oxford Space Systems, United Kingdom (Great Britain))

8:40 ***5G Multi-User System Simulations in Line-of-Sight with Space-Tapered Cellular Base Station Phased Arrays***

Yanki Aslan (Delft University of Technology, The Netherlands); Salman Salman (TU Delft, The Netherlands); Jan Puskely (Delft University of Technology, The Netherlands); Antoine Roederer (Technical University of Delft, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

The performance of space-tapered multi-beam arrays with minimized side lobe levels is statistically evaluated in a line-of-sight propagation environment within a cell sector in terms of the signal-to-interference-plus-noise ratio at the multiple user ends. Comparative analyses are performed to examine the advantages of space-tapered, irregular arrays over the conventional regular array layouts. The system model is formulated with a meaningful link-budget analysis. Two different precoding techniques, conjugate beamforming and zero-forcing, are applied to compute the excitation coefficients at the antenna elements. The effects of several practical factors such as approaches in user scheduling, errors in channel state information estimation and quantization in excitation amplitudes and phases are studied. The simulation results indicate that space-tapered arrays with conjugate beamforming statistically perform better than the regular counterparts and can achieve similar performance to zero-forcing precoding when the impact of non-ideal system conditions is considered.

9:00 ***Synthesis of Multi-Beam Space-Tapered Linear Arrays with Side Lobe Level Minimization in the Presence of Mutual Coupling***

Yanki Aslan (Delft University of Technology, The Netherlands); Massimo Candotti (Independent Consultant, United Kingdom (Great Britain)); Alexander Yarovoy (TU Delft, The Netherlands)

An iterative convex element position optimization algorithm is proposed for linear phased array synthesis with the aim of minimizing the side lobe level at multiple scan angles in the presence of mutual coupling. Embedded element patterns are obtained via full-wave simulations and integrated into the optimization procedure. A two-step optimization scheme with a smart initial array layout selection is proposed and analyzed. Conventional H-plane patch antenna arrays are used for algorithm demonstration. The simulation results show that via position-only optimization, the maximum side lobe level can be significantly decreased compared to the benchmark regular arrays with a half-wavelength spacing while keeping a similar total array length.

9:20 ***Ultrawide Band Tightly-Coupled Aperture Magneto-Electric Dipole Array over 20 - 40 GHz***

Sadegh Mansouri Moghaddam, Ashraf Uz Zaman and Jian Yang (Chalmers University of Technology, Sweden); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

We propose a linearly-polarized wideband phased- array for millimeter-wave applications. The array is composed of tightly-coupled Magneto-Electric Dipoles fed by slot-coupled microstrip lines. The integration of the radiating elements with the feed structure removes the need of an external balun and simplifies the manufacturing process. The simulated antenna provides 64% bandwidth at VSWR < 2 and 60% bandwidth at VSWR < 2.65 for scanning up to 45◦ and 60◦ in both E- and H-planes, respectively.

9:40 ***A Study of C-Band 1-Bit Reconfigurable Dual-Polarized Transmitarray***

Irina Munina and Pavel A. Turalchuk (St. Petesburg Electrotechnical University LETI, Russia); Alexey Shitvov (Cardiff University, United Kingdom (Great Britain))

A simple structure of reconfigurable unit cell is proposed for 1-bit transmitarrays in the C-band. It consists of two square ring patches capacitively coupled to U-shaped microstrip resonators, all implemented on a 5-layer printed circuit board. The resonators on one side of the unit cell are connected to the resonators on the other side through vias. The structure can operate on dual linear polarized waves and features minimum number of vias, low insertion loss and a 2.8% fractional bandwidth. The change of the phase state between 0° and 180° is implemented with PIN diode switches. The unit cell simulation results are validated by measurements of a stand-alone unit cell in a rectangular waveguide. In both phase states, the transmission and reflection coefficients have very similar values with the minimum insertion loss of 1.7 dB and 1.9 dB at 5.9 GHz in the phase states of 180° and 0°, respectively. Application of the proposed unit cell for 1-bit reconfigurable transmitarrays is discussed and the effects of the phase quantization are evaluated numerically.

10:00 ***Stacked Patch Antenna and Hybrid Beamforming Network for 5G Picocell Applications***

Danelys Rodríguez-Avila (Microwave and Antenna Group (MAG), Ecole Polytechnique Fédérale de Lausanne, Switzerland); Anja K. Skrivervik (EPFL, Switzerland)

This paper addresses the design of an antenna array for a portable picocell station with omnidirectional coverage. The proposed solution includes a stacked patch antenna as single radiating element of the antenna array and a hybrid beamforming network. The antenna element works in 26 GHz with a bandwidth of 20% and a gain of approximately 8.5 dB along the operational bandwidth. The antenna is fed by a suspended stripline transitioned from a waveguide. This antenna element is used to compute a 5x12-antenna array fed by the hybrid beamforming network. Results are analytically obtained for a fixed analog beamforming network that generates a csc2 pattern shape in elevation. Additionally, a digital beamforming network is computed to perform beamsteering for a desired set of constraints in the azimuthal plane. Simulated results of the complete system yield promising insights on the capacity of the proposal to provide omnidirectional coverage.

L_A02 Array Ant: L_A02 Array antennas, antenna systems and architectures

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Nima Jamaly (Swisscom, Switzerland), Fermin Mira Perez (Centre Tecnologic de Telecomunicacions de Catalunya, Spain)

8:40 ***Antenna System Optimization for Active Metamaterial-enhanced Magnetic Induction Communications***

Zhangyu Li (University at Buffalo, USA); Zhi Sun (State University of New York at Buffalo, USA)

Magnetic induction (MI) communication are widely used in applications in extreme environments, including environment surveillance, past disaster rescue, and resource detection since it does not suffer from high material absorption in lossy media. However, existing MI systems rely on high transmitting power and large antenna to reach practical communication range. Recently, metamaterial enhanced MI (M2I) communication was proposed, which can increase the signal strength of the original MI system to 30 dB in theory. However the latest practical implementation of M2I system only achieves an 8 dB gain due to the metamaterial loss. In this paper, the active metamaterial unit is introduced to the current M2I communication system to close the performance gap between theoretical and practical results. The antenna system is optimized based on the rigorously model of circuit, coil array structure and channel. Through analytical deduction and COMSOL simulations, the proposed active M2I antenna system shows significant power gain and improvement in communication range compared with the passive M2I system and the original MI system.

9:00 ***Design of Sparse Dome Antenna Array for Angle of Arrival Localization Systems***

Tatiana Pavlenko (University of Erlangen-Nuremberg, Germany); Martin Schütz (University of Erlangen-Nuremberg & Institute of Microwaves and Photonics, Germany); Yassen Dobrev (Symeo GmbH, Germany); Martin Vossiek (LHFT, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

A design of a conformal 16-element patch array with antennas non-uniformly distributed over a hemispherical surface is presented. The considered array type allows 3D positioning by angle of arrival (AOA) in hemispherical angular coverage that is desired for localization of UAV and other mobile robots in GNSS-denied environments. At the same time, the optimization of antenna positions helps to highly reduce the number of antennas needed to achieve suitable localization accuracy in desired angular range. The realized array was integrated as a receive array of a 24 GHz local positioning radar unit. Calibration and measurement results with transponder mounted on a 6D positioning system show the applicability of such type of highly sparse conformal array for use in 3D local positioning systems. Thus, the presented array introduces a cost-effective design solution for wireless localization within hemispherical coverage utilizing only two positioning units.

9:20 ***A Circular Polarization Patch Array Designed for a Sentinel-1 SAR Transponder***

Guido Luzi (Centre Tecnològic de Telecomunicacions de Catalunya Av. C F Gauss 7 Castelldefels, Spain); Roger Ferré (Centre Tecnològic de Telecomunicacions de Catalunya, Spain); Fermin Mira Perez (Centre Tecnologic de Telecomunicacions de Catalunya, Spain)

This paper reports the design and preliminary test of a circular polarized patch array antenna operating in C band. The antenna was designed as part of a C band Active Corner reflector (ACR). The operating band is 5.405 GHz ± 50 MHz band, the same used by ESA Sentinel-1 SAR. The main requirements for the antenna system are: a simple design to assure an adequate phase stability, simple installation, and low cost, as requested for the proposed ACR.

9:40 ***Application of Sequential Rotation Technique on Monopulse Radar Antennas***

Korbinian Schraml and Dirk Heberling (RWTH Aachen University, Germany)

In this paper an investigation of the effects of the sequential rotation technique on the sum and difference patterns of monopulse radar antennas is presented. A LHCP polarized test antenna is designed and simulated and used to build linear arrays in different configurations. 10 cases for sum pattern with amplitude uniform and tapered amplitude distributions as well as 6 cases for difference pattern are compared in beam direction, beam width and axial ratio. The results show an influence on the pattern in particular for tapered sum patterns and difference patterns.

10:00 ***Two-Dimensional Phase Retrieval as a 'Crosswords' Problem***

Andrea Francesco Morabito (University Mediterranea of Reggio Calabria, Italy); Pasquale Nicolaci (Space Engineering S.p.A., Italy); Roberta Palmeri (Università Mediterranea of Reggio Calabria, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

By taking advantage of existing knowledge and approaches for the retrieval of a 1-D discrete signal from the intensity of its Fourier Transform, we introduce an innovative method for the solution of the corresponding 2-D problem. By exploiting only one measurement surface, and without recurring to global-optimization algorithms, the approach is able to find in a deterministic fashion all the different solutions of the problem.

R_A02 Slot & leaky-wave ant: R_A02 Slotted and leaky-wave antennas

TOP

Radars / Regular Session / Antennas

Room: Oral Sessions: S4-D - Bytom

Chairs: Thomas Bertuch (Fraunhofer FHR, Germany), Erio Gandini (TNO, The Netherlands)

8:40 ***A Model for Equivalent Loss Tangent of Multilayered Media for Automotive Radar Applications***

Jogesh Chandra Dash (Indian Institute of Technology Bombay, India); Shilpa Kharche (Indian Institute of Technology, Bombay, India); Jayanta Mukherjee (Indian Institute of Technology Bombay); Vivek Dhoot and Ranga Makanaboyina (Daimler-Mercedes Benz Research & Development India, India)

In this paper, a mathematical equation to obtain the effective loss tangent of a multilayered medium is derived. This equation is applied to obtain the effective loss tangent of a car bumper with multiple paint layers on it. The equation is derived using two models - a parallel plate capacitor model and a transmission/reflection coefficient model. The accuracy of the equation is verified and compared using EM simulations. For the EM simulation we use two structures one where both bumper and paint materials are replaced by a single effective medium and the other where only the paint layers are replaced by a single effective medium, while the bumper is kept as it is. The EM simulations have been performed at the 77 GHz frequency band (Automotive collision avoidance radar). The simulation time for antenna gain is reduced by 88 % and 57 % for an antenna in the presence of the first and second EM structures respectively. The antenna gain obtained using the second EM structure shows a near 100 % match with that of the actual multilayered bumper and paint structure.

9:00 ***Slotted Waveguide Antenna Integrated with Printed Yagi-Uda Director Array***

Taher Badawy (Fraunhofer Institute for High Frequency Physics FHR, Germany); Thomas Bertuch (Fraunhofer FHR, Germany)

This paper presents an edge slotted waveguide antenna integrated with a printed Yagi-Uda director array. The antenna array is composed of ten inclined slot radiators operated at a center frequency of 2.925 GHz. The proposed printed Yagi- Uda director array is used as a different approach to the sectoral horn or the dielectric slab waveguide to achieve a directive beam in the vertical plane. A low sidelobe level in the horizontal plane is obtained by applying Taylor's distribution. To reduce the sidelobe level of the proposed antenna in the vertical plane, the lengths of the elements of the printed Yagi-Uda director array are linearly tapered. The antenna array is fabricated and measured in an anechoic chamber to verify the proposed approach.

9:20 ***Double Periodic Composite Right/Left Hand (CRLH) Substrate Integrated Waveguide (SIW) Based Leaky Wave Antenna with Extended LH Region***

Karthik Thothathri Chandrasekaran, Arokiaswami Alphones and Faeyz Karim (Nanyang Technological University, Singapore); N Nasimuddin (Institute for Infocomm Research, Singapore)

In this work, a double periodic composite right/left Hand (CRLH) leaky wave antenna is proposed to have continuous backward to forward beam-scanning with the slope of the main beam direction with respect to the frequency almost equal in the left handed (LH) and the right handed (RH) regions. This is achieved by obtaining a dispersion that has almost identical slope in the LH region as well as the RH region. An additional RH leaky wave region is also obtained as a consequence of the double periodic structure. A dispersion diagram analysis is performed to design the double periodic unit cell to have the desired characteristics. The overall size of the antenna is 5.16lambda_0*0.8lambda_0*0.0271lambda_0. The antenna has three distinct operating regions. The first RH leaky wave region extends from 5.7 to 6.73GHz with a scanning range extending from 30 degrees to 65 degrees. The LH leaky wave region extends from 7.6 to 10.37GHz with a scanning range extending from -55 to 0 degrees and a gain > 5dBi. The RH leaky wave region extends from 10.37 to 13.87GHz with a scanning range extending from 0 to 40 degrees and a gain>8dBi. The slope of the main beam direction with respect to the frequency in the LH region and RH region are 20.37(degrees/GHz) and 28.57(degrees/GHz) respectively. The antenna exhibits consistent beam-scanning from the backward to forward direction with an extended LH region. Measurement results correlate well with the simulation results.

9:40 ***Design of a Dual-Mode Operation 2-D Periodic Planar Leaky-Wave Antenna***

Davide Comite (Sapienza University of Rome, Italy); Victoria Gómez-Guillamón Buendía (Heriot-Watt University, United Kingdom (Great Britain)); Walter Fuscaldo (Sapienza University of Rome, Italy); Zain Shafiq (Heriot Watt University, United Kingdom (Great Britain)); Symon K. Podilchak (Heriot-Watt University, United Kingdom (Great Britain)); Paolo Burghignoli (Sapienza University of Rome, Italy); Paolo Baccarelli (Roma Tre University, Italy); Alessandro Galli (Sapienza University of Rome, Italy)

In this contribution, we describe the design and the radiation features of a dual-mode operation low-profile, low-cost, wide-band antenna. The structure is made by an annular, 2-D radially periodic, leaky-wave antenna enabling the generation of both high-gain beams in the far-field and of non-diffracting waves within the near-field radiative region. This is obtained through the generation of a fast backward spatial harmonic supported by a metal-strip grating placed on a grounded dielectric slab. The radiation can be then described by means of a cylindrical leaky-wave dominating the aperture field of the antenna, whose dispersive behavior is properly taken into account. The high-gain radiation features and the focusing capabilities of the device are experimentally investigated and described. Thanks to the dual-mode capability, the proposed design represents an attractive, simple, and innovative solution for next-generation of wireless power transfer device, for tracking or automotive anti-collision systems as well as for advanced microwave imaging. Index Terms-Leaky waves, near field, dual-mode

10:00 ***Signal to Noise Ratio for a Pico-Seconds Pulsed Radar for Imaging at Stand-Off Distances***

Arturo Fiorellini Bernardis, Paolo Sberna, Andrea Neto and Nuria LLombart (Delft University of Technology, The Netherlands)

Recently powerful, reliable and cost-effective THz radiation micro-emitters have been developed. These innovative sources have been proven to be capable of providing up to 1 mW of pulsed power in the range of frequencies between 0.1 and 0.7 THz. In this paper we present a study of the possible Signal to Noise Ratio using such sources in an ideal non dispersive channel such a coplanar waveguide where the main noise source is assumed to be the Johnson thermal. The purpose of the investigation is to identify the budget margin available for a realistic radar channel for future imaging applications. The image acquisition speed is the driving parameter fixed of 10 Hz. It emerges that adopting an array of 30×30 elements, and accounting for a SNR_min=20 dB for a realistic quasi-optical channel configuration, 100 points in the longitudinal direction can be scanned in real time while having a room of 23 dB left for the design.

Wednesday, April 3 8:40 - 12:30

CS7 IET / COST session CA15104 (IRACON): CS7 IET / COST session CA15104 (IRACON): Propagation measurements and modelling for 5G and beyond

TOP

High Data-rate Transfer / Convened Session / Propagation

Room: Oral Sessions: G1- Gniezno

Chairs: Sana Salous (Durham University, United Kingdom (Great Britain)), Enrico M. Vitucci (University of Bologna, Italy)

8:40 ***A Study on Dual-Directional Mm-wave Indoor Channel Characteristics***

Enrico M. Vitucci, Fan Yu, Leonardo Possenti and Marco Zoli (University of Bologna, Italy); Franco Fuschini (DEI - Bologna, Italy); Marina Barbiroli and Vittorio Degli-Esposti (University of Bologna, Italy); Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany); Thomas Kuerner (Braunschweig Technical University, Germany)

The dual-directional characteristics of propagation in a medium-size indoor environment at two frequency bands, 10 GHz and 60 GHz, are assessed in this work through directional measurements and ray tracing simulation. Ray Tracing is used as a tool to interpret measurement results, but also as a propagation model to simulate mm-wave propagation. For what concerns the latter aspect, ray tracing has been calibrated vs. measurements and the accuracy in terms of dual-directional simulation of the channel has been evaluated.

9:00 ***300 GHz Channel Characterization of Chip -to- Chip Communication in Metal Enclosure***

Jinbang Fu, Prateek Juyal and Alenka Zajic (Georgia Institute of Technology, USA)

This paper presents the characterization of Terahertz (THz) wireless channel inside a desktop size metal box with focus on line-of-sight (LoS) and reflected-non-line-of-sight (RNloS) propagation. Measurements for LoS propagation inside the metal box show that path loss varies with respect to the transceiver's height from the bottom wall, and for some heights, the path loss is lower than the free space value. By analyzing the relationship between the path loss and the antenna's height, the results show that the first six modes of TE mode dominate the resonating modes inside the box. Also, the path loss analysis indicates that the resonating modes combined with the reflections happened inside the box should be responsible for the strong ripples on the path loss curve. Finally, the RNLoS measurements with dual-in-line-memory-module (DIMM) as the reflecting surface show that the differences between the average path losses measured inside the metal box and in free space are limited to 1 dB.

9:20 ***Indoor 1-40 GHz Channel Measurements***

Maria-Teresa Martinez-Ingles (University Centre of Defence at the Spanish Air Force Academy, MDE-UPCT, Spain); Juan Pascual-García (Universidad Politécnica de Cartagena, Spain); Davy P Gaillot (University of Lille, France); Concepcion Sanchis Borras (University San Antonio from Murcia, France); Jose-Maria Molina-Garcia-Pardo (Universidad Politécnica de Cartagena, Spain)

This work presents a multidimensional measurement campaign from 1 GHz to 40 GHz in an indoor environment. MIMO channel transfer functions were obtained using a Vector Network Analyzer and Optical-Radio transceivers. The Path Loss, RMS delay spread and K factor were computed from measured data. One of the main novelties in this contribution is the channel sounder, where 39 GHz are measured simultaneously, without distance limitation due to use of fiber optics

9:40 ***Clutter Loss Measurements and Simulations at 26 GHz and 40 GHz***

Belen Montenegro-Villacieros (European Commission - Joint Research Center, Italy); James Bishop and Jean Marc Chareau (Joint Research Centre of the European Commission, Italy)

The World Radiocommunication Conference 2015, WRC-15, identified candidate frequency bands between 24.25 GHz and 86 GHz for future 5G systems. The Radio Spectrum Policy Group of the European Commission selected the 26 GHz band as pioneer for introducing next-generation 5G terrestrial wireless systems in the Union, and the 32 GHz and 40 GHz bands as promising and viable options in the longer term for 5G use. Sharing and compatibility studies for assuring the protection of services to which these bands are allocated on a primary basis are required before the WRC-19 allocates these frequencies to 5G services. These studies need propagation models to calculate interference levels at receivers. New propagation models are needed for the new frequencies and scenarios identified for 5G. New propagation models are developed through simulations or experimental measurement campaigns, each method having its pros and cons. The Joint Research Centre has started an activity working on both. This paper presents preliminary findings on use of a ray-tracing tool to produce clutter loss data and first comparisons with real experimental data, with the aim of validating the ray-tracing tool for the generation of new clutter loss data.

10:00 ***Directional Delay Spread Characteristics of Outdoor-to-Indoor Propagation Based on Millimeter-Wave Measurements***

Juyul Lee, Kyung-Won Kim, Myung-Don Kim and Jae-Joon Park (ETRI, Korea)

This paper empirically investigates the directional delay spread characteristics for outdoor-to-indoor (O2I) propagation environments. These directional characteristics are obtained by considering only a particular portion of multipath components (rather than considering all the omnidirectional multipath components) that are spatially filtered by a narrow-beamwidth antenna. In millimeter-wave systems, directional characteristics are useful when employing high-gain directional beamforming techniques. Based on 32 GHz O2I measurements conducted in two building sites, which were carefully selected to follow the ITU-R building classification, we extract directional delay dispersion characteristics as a function of changes in antenna beamwidth. Our analysis results show that the root-mean-square (r.m.s.) directional delay spread characteristics are dependent not only on building type but also on antenna beamwidth. Interestingly, the thermally efficient building exhibits more dispersive characteristics than the traditional building, which is due to a smaller peak multipath component (MPC). The r.m.s.~delay spread increases as the antenna beamwidth increases, since a wider beamwidth antenna captures more MPCs. These characteristics will be useful for the determination of dynamic cyclic-prefix length in an OFDM-based system.

10:20 Coffee Break

10:50 ***62.5-GHz Phased-Array Channel Sounder for Double-Directional Angle Estimation***

Peter Papazian, Derek Caudill, Camillo Gentile, Jack Chuang and Nada Golmie (NIST, USA)

The paper describes implementation of phased array antennas for use in a channel sounding system. The antennas are prototype array operations at 62.5 GHz printed on a circuit board. Each array boards two 16 element arrays with separate RF ports and IF sections which can scan ±45° with a fixed elevation beamwidth. The system uses 4 boards at the receiver oriented at 90° to allow omni direction coverage when scanning. The receiver consists of two boards also implemented at 90° allows 180° transmitter coverage. Using a timing system and Rubidium clocks at both the transmitter and receiver this enables direction of departure and direction of arrival multipath measurements. The objective of the system is to test prototype phased array boards and tracking algorithms which rely on array antennas narrow beamwidth and scanning abilities at millimeter wave frequencies

11:10 ***Frequency Selectivity of Window Attenuation Up to 100 GHz***

Jonas Medbo and Satyam Dwivedi (Ericsson Research, Sweden)

This paper presents highly accurate measurements of glass pane attenuation for radiowave transmission in the range 5-60 GHz. For this purpose, a measurement setup and analysis method for minimizing the impact of multipath in a scattering environment has successfully been developed. The obtained results match perfectly the textbook theory for multilayer slabs provided by ITU-R Recommendation P.2040. Moreover, the P.2040 model for complex permeability, including parameter values for glass, matches the measurements very well. Only slight adjustments of corresponding parameter values are required in some cases. Also, in the case of metalized glass the match between model and measurements is very good. The perfect match between model and measurements proves that the modelling provided in P.2040 is reliable for use in any window attenuation simulations. Though no measurements were performed for multiple panes it is expected that the model is valid also for this case.

11:30 ***Development and Experimental Validation of an Ultra-wideband Channel Sounder***

Wei Fan (Aalborg University, Denmark); Allan Mbugua (University of Cassino and Southern Lazio, Italy); Xuesong Cai and Kim Olesen (Aalborg University, Denmark)

Vector network analyzer (VNA) has been extensively utilized for radio channel sounding purposes. Due to its slow channel sounding speed, it has been mainly used for channel measurements in static propagation scenarios. The main limitation with VNA based channel sounder is its small measurement range, due to signal attenuation in the coaxial cable setup. Employing radio over fiber (RoF) can effectively eliminate the cable loss and hence enables the VNA for long range channel sounding. However, optical cables are sensitive to phase changes in optical cables in practical usage scenarios. In this paper, two phase correction strategies, i.e. two-branch scheme and bi-directional scheme, are discussed and experimentally validated to remove the random phase change in the cable. The bi-directional scheme is shown to be highly effective in removing the phase change in the measurements. The virtual array VNA channel sounder employing RoF technique and phase correction scheme is highly attractive, since it supports channel sounding with arbitrary frequency carrier setting, ultra-wideband, large-scale (virtual) antenna settings with a large measurement range.

11:50 ***Impact of Precipitation on Millimetre Wave Fixed Links***

Sana Salous, Yusheng Cao and Xavier Raimundo (Durham University, United Kingdom (Great Britain))

The paper gives an overview of the experimental set up to study the impact of precipitation on fixed links in the 25.84 GHz and 77.52 GHz bands. Preliminary results of dual polarised measurements are presented with disdrometer data which give several parameters including rain-fall rate and drop size distribution. The measurements are compared with two models based on the rain data parameters.

12:10 ***Development of a Nation-Wide Research Platform for Dynamic Spectrum Access (DSA)***

Albert A. Lysko (Council for Industrial and Scientific Research & CSIR Meraka Institute, South Africa); Luzango Mfupe and Mofolo Mofolo (Council for Scientific and Industrial Research (CSIR), South Africa); David L Johnson (University of Cape Town & Ammbr Research Labs South Africa, South Africa); Lebogang Rakgolela, Gabriel Montja, Mla Vilakazi, Sydney Sebopetse and Nosipho Khumalo (Council for Industrial and Scientific Research, South Africa); Magdeline Lamola and Natasha Zlobinsky (University of Cape Town, South Africa)

The paper overviews the progress made in developing a country-wide research platform for spectrum monitoring - assisted dynamic spectrum access (DSA) in South Africa, with 6 universities participating. The paper also describes a simple method of incorporating this "spectrum sensing" type of inputs into GLSD decision making towards robust and accurate allocation of spectrum bands in real time.

Wednesday, April 3 8:40 - 10:20

W_A05 WN Ant: W_A05 Wireless Networks Antennas

TOP

Wireless Networks and Defense and Security / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Karu Esselle (Macquarie University, Australia), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

8:40 ***A Comprehensive Study of Weaving Structure and Its Impact on Textile Antenna for WBAN Application***

Norsyahirah Izzati Zaidi (Antenna Research Group, Universiti Teknologi MARA, Malaysia); Mohd Tarmizi Ali Ali and Mohd Tarmizi Ali (Universiti Teknologi Mara, Malaysia); Nurul Huda Abd Rahman, Mohamad Faizul Yahya and Aidil Azwan Sharatol Ahmad Shah (Universiti Teknologi MARA, Malaysia); Muhammad Shakir Amin Nordin (MARA University of Technology, Malaysia)

Weaving structure on conductive fabric or e-textile has not yet being investigate thoroughly. Previous studies on textile antenna usually use the market conductive fabric. Least study was present on the weaving structure of the conductive fabric and it is actually important especially if the conductive fabric is develop from the start. Thus, this paper study the structure of three weaving patterns which are plain, satin and twill for the development of conductive fabric. Three prototypes were fabricated and the performance of textile antenna is observed at resonance frequency 3 GHz. At the end of the experiment, it is prove that weaving structure does affect the antenna performance. Satin and twill shows better gain performance compared to plain weave pattern. The gain of satin and twill weaving structure are 3.22 dB and 3.23 dB respectively, while plain weave is 2.25 dB. More theory on how weaving pattern affects the antenna will be discuss on this paper.

9:00 ***Improved Dual Polar Orthogonality Using Elliptically Polarised Patch Antenna Design***

Intan Zainal Abidin (Universiti Sains Malaysia, Malaysia); Tim Brown (University of Surrey, United Kingdom (Great Britain))

The channel orthogonality of a dual polar MIMO system is an important parameter to minimize the interference between polarisations. Polarisation multiplexing can greatly enhance a MIMO channel in a fixed link, normally using linear or circular polarisation. Due to imperfections, a practical antenna can never achieve polarisation purity to be perfectly linear or circular, therefore elliptical polarisation will be radiated instead. By exploiting this imperfection, this paper presents an elliptically polarised diagonal slotted patch antenna and shows the improvement in orthogonality achieved by deliberately creating elliptical polarisation. Other patches that could be considered linearly and circularly polarised were also fabricated as the reference antenna. Measured results verified that elliptically polarised antennas achieved improved reduction in cross talk of over 20dB compared to antennas intending to be linear or circular. Such improvements in orthogonality show that the theoretical 2x2 MIMO capacity limits can practically be reached in a fixed link.

9:20 ***Electromagnetic Energy Harvesting Systems in the Railway Environment: State of the Art and Proposal of a Novel Metamaterial Energy Harvester***

Mohammed Kalaagi, III (Universite Lille 1 & The French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks, France); Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France)

In this paper, an overview on energy harvesting systems in the railway environment and recent advancements is presented, as well as a design of a high efficient subwavelength metamaterial energy harvester is proposed and designed at 350 MHz compatible for railway applications. Energy harvesting systems in the railway environment vary from piezoelectric energy harvesters to electromagnetic energy harvesting systems (mostly mechanical vibrations to electric energy) which has been an interesting topic for researchers specially for applications to supply power to wireless sensor networks to insure safety on the railway track. Recently, experimental measurements have been observed for electromagnetic fields in the railway environment at a wideband range of frequency from 10 kHz to 1 GHz where unintentional signals or ambient energy has shown to exist in the railway infrastructure. Thus, we consider the design of a high efficient and compact energy harvesting system based on metamaterials at a given frequency compatible for railway applications which is chosen at 350 MHz. The metamaterial design has shown full absorption at 350 MHz equal to 98% with a subwavelegth structure of $\lambda/14$ and thickness $\lambda/100$. Unlike metamaterial absorbers, the energy is dissipated through a VIA where 84% of the energy was delivered through a resistive load of 8.5 KΩ.

9:40 ***5G mmW Receiver Interoperability with Wi-Fi and LTE Transmissions***

Marko E Leinonen and Marko Sonkki (University of Oulu, Finland); Olli Kursu (Centre for Wireless Communications, University of Oulu, Finland); Aarno Pärssinen (University of Oulu, Finland)

In the future, 5G millimeter wave radios will be integrated into mobile devices and small cell base stations with other radios and this will introduce new interoperability problems. Current LTE (Long Term Evolution) and Wi-Fi radio transceivers have not been designed, verified or specified for simultaneous operation with 5G mmW radios. Wi-Fi or LTE-LAA (Licensed Assisted Access) may introduce co-channel interference due to the harmonics falling over 5G mmW frequencies. Alternatively, the fundamental transmission may block the 5G mmW receiver. This paper studies requirements for RF filtering in the LTE-LAA and Wi-Fi radios, which operate in conjunction with a 5G mmW system. Antenna isolation measurements of 5G proof-of-concept (PoC) antenna array show that mmW antenna array resonates with multiple lower frequencies due to the antenna array physical dimensions, e.g. overall module dimensions, sub-array dimensions and sub-array locations from the edges of the antenna module, leading to new interference problems. Thus, lower frequency interoperability is a new optimization criterion for mmW antenna module dimensions. Measurement results verify that a previously developed 5G mmW POC radio operating at 28 GHz and LTE-LAA/Wi-Fi operating at 5 GHz as well as LTE at 2.7 GHz can operate simultaneously without interference problems within the same radio unit.

10:00 ***Compact Dual Band Antenna for Off-Body-Centric Communications***

Ali Araghi (University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); Amirhossein Alizadeh Ghannad (University Of Surrey, United Kingdom (Great Britain)); Pei Xiao and Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))

A compact size, dual-band wearable antenna for off-body communication operating at the both 2.45 and 5.8 GHz industrial, scientific, and medical (ISM) band is presented. The antenna is a printed monopole on the FR4 substrate with a modified loaded ground plane to make the antenna profile compact. Antennas' radiation characteristics have been optimized while the proposed antenna placed close to the human forearm. The fabricated antenna operating on the forearm has been measured to verify the simulation results.

Wednesday, April 3 8:40 - 12:30

CS30 Diagnosing & treating with microwaves: CS30 Diagnosing and treating with microwaves - new findings covering tissue dielectric properties, medical imaging and patient studies

TOP

Biomedical / Convened Session / Propagation

Room: Oral Sessions: A2- Ustka

Chairs: Angie Fasoula (Microwave Vision Group, France), Declan O'Loughlin (National University of Ireland Galway, Ireland)

8:40 ***Wavelia Microwave Breast Imaging: Identification and Mitigation of Possible Sources of Measurement Uncertainty***

Luc Duchesne (MVG Industries, France); Angie Fasoula (Microwave Vision Group, France); Evgueni Kaverine, Guillaume Robin and Jean-Gaël Bernard (MVG Industries, France)

This paper outlines the identification and characterization of the principal sources of measurement uncertainty in the Wavelia Microwave Breast Imaging experimental prototype, which will be used in a first-in-human clinical investigation at Galway University Hospital, Ireland. A first approach for identifying the various error sources is provided. The contributions of the thermal environment, the mechanical movements and the system noise floor are described in more detail. Solutions to mitigate these error contributions are also presented and briefly commented.

9:00 ***Improving the Diagnostic Capability of Microwave Radar Imaging Systems Using Machine Learning***

Tyson Reimer, Jorge Sacristán and Stephen Pistorius (University of Manitoba, Canada)

Breast microwave sensing (BMS) is a potential breast cancer detection technique that uses low-power microwave radiation to detect the presence of cancerous lesions. This work presents the results of the application of a multilayer perceptron (MLP) and support vector machine with radial basis function (SVM RBF) to breast cancer detection for a portable BMS prototype. Numerical 2D phantoms belonging to either BI-RADS Class 1 or Class 2 classifications were used to produce simulated data as collected by the portable system using an array of twelve sensors operating at five frequencies between 2.3 GHz and 6.5 GHz. Five feature preprocessing pipelines and their impact on classification performance were evaluated. An area under the curve of the receiver operating curve (ROC AUC) as high as (95 ± 1)% for BI-RADS Class 1 and as high as (94 ± 1)% for BI-RADS Class 2 were obtained using the SVM RBF, and as high as (94 ± 1)% for Class 1 and (92 ± 2)% for Class 2 using the MLP.

9:20 ***An Innovative Framework for Advancing Microwave Medical Imaging: The EMERALD European Network***

Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Francesca Vipiana (Politecnico di Torino, Italy)

Nowadays, medical imaging technologies play a key role to face the ever-growing number of challenges due to aging populations, as they are the essential clinical tool to deliver accurate initial diagnosis and monitor the evolution of disease over time. For this reason, a whole range of new imaging modalities is currently being developed to supplement and support current modalities. This communication introduces the recently started "EMERALD - ElectroMagnetic imaging for a novel genERation of medicAL Devices" project, which is a European network of nested doctoral projects pursuing the development innovative medical imaging devices based on electromagnetic technology. The original implementation of the network structure and the highly focused nature of each project is such that the global resultant of this European research effort may provide a systemic answer to some emerging clinical needs.

9:40 ***2-D Experimental Testing of a Microwave Imaging System Designed for Cerebrovascular Diseases Monitoring***

Jorge A. Tobon Vasquez (Politecnico di Torino, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Gennaro Bellizzi (University of Naples Federico II, Italy); Nadine Joachimowicz (Group of Electrical Engineering - Paris / CentraleSupelec, France); Bernard Duchêne (Laboratoire des Signaux et Systèmes/Supèlec/CNRS, France); Mario Roberto Casu (Politecnico di Torino, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Francesca Vipiana (Politecnico di Torino, Italy)

This paper describes the performed 2-D experimental testing on a microwave imaging system, designed for cerebrovascular diseases monitoring. Two different imaging algorithms have been implemented and compared. A good agreement between the reconstructed images and the real target position and size has been obtained.

10:00 ***An Empirical Dielectric Mixing Model for Biological Tissues***

Saqib Salahuddin and Barry McDermott (Translational Medical Device Lab, National University of Ireland Galway, Ireland); Emily Porter (National University of Ireland Galway & Translational Medical Device Lab, Ireland); Martin O'Halloran, Muhammad Adnan Elahi and Atif Shahzad (National University of Ireland, Galway, Ireland)

Dielectric properties of biological tissues are critically important for various electromagnetic based medical therapeutic and diagnostic technologies. This paper attempts to develop an empirical dielectric mixture model using the classical dielectric mixture theory and water content information to estimate the in-vivo dielectric properties of biological tissues over the microwave frequency range.

10:20 Coffee Break

10:50 ***Investigating Human Bone Microarchitecture and Dielectric Properties in Microwave Frequency Range***

Bilal Amin (National University of Ireland, Galway & Translational Medical Device Lab, Ireland); Atif Shahzad (National University of Ireland, Galway, Ireland); Laura Farina (National University of Ireland Galway & CURAM, Ireland); Eoin Parle, Laoise McNamara, Martin O'Halloran and Muhammad Adnan Elahi (National University of Ireland, Galway, Ireland)

Dielectric properties of bones are proposed to monitor bone quality. However, no study has investigated the relationship between bone dielectric properties and microarchitecture of bone, which is of paramount importance for bone quality assessment. This paper reports the first in-vitro investigation of relationship between dielectric properties of human trabecular bone (n = 45) and its microarchitecture parameters (trabecular number, trabecular thickness and trabecular spacing). The objective of the study was to investigate the difference between osteoporotic (n = 23) and osteoarthritis (n = 22) patients in terms of microarchitectural parameters and dielectric properties and to examine any relationship between microarchitectural parameters and dielectric properties. A significant difference was observed between osteoporotic and osteoarthritis patients in terms of microarchitecture parameters. The trabecular number and trabecular thickness were found to be significantly high for osteoarthritis patients in comparison to osteoporotic patients. The percentage difference for trabecular number and trabecular thickness between both patients group was found to be 27% and 31% respectively. Trabecular spacing was lower in osteoarthritis patients compared to osteoporotic patients. Similar differences were also observed between both patients group in terms of dielectric properties. More importantly, the dielectric properties were significantly higher for osteoarthritis patients than osteoporotic patients with a percentage difference of 42% and 32% at 900 MHz in terms of relative permittivity and conductivity respectively. These preliminary findings support the idea of using dielectric properties to as a method to differentiate bone quality.

11:10 ***Clinical Study with a Time-Domain Microwave Breast Monitor: Analysis of the System Response and Patient Attributes***

Lena Kranold, Collin Quintyne, Mark Coates and Milica Popović (McGill University, Canada)

This paper presents statistical results of a clinical trial with a multistatic time-domain microwave breast health monitor. The wearable prototype was tested on patients that reported a previous abnormality on a mammogram or MRI. Within this study, we investigate the correlation between system response and patient specific data like breast size, breast density, and age. The goal is to determine if certain patient attributes result in a specific signal response, thereby identifying avenues for optimization of the overall prototype, all with the aim of improving signal quality.

11:30 ***Comparison of Coaxial Open-Ended Probe Based Dielectric Measurements on Ex-Vivo Thermally Ablated Liver Tissue***

Giuseppe Ruvio (National University of Ireland, Galway, Ireland); Laura Farina (National University of Ireland Galway & CURAM, Ireland); Anna Bottiglieri (Translational Medical Device Lab & National University of Ireland, Galway, Ireland); Jimmy Eaton-Evans (National University of Ireland Galway, Ireland); Muhammad Adnan Elahi and Martin O'Halloran (National University of Ireland, Galway, Ireland); Rosanna Pinto (ENEA, Italy); Vanni Lopresto (ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy); Marta Cavagnaro (Sapienza University of Rome, Italy)

This paper compares an in-house measurement system based on the "Stuchly and Stuchly" method with the broadly commercialised Keysight setup and existing literature for the characterization of ablated and non-ablated liver tissue. Measurements were carried out on ex-vivo ovine liver tissue across the frequency range 0.5 - 4.5 GHz. Results show that the in-house "Stuchly & Stuchly" method using calibration standards such as deionised water, methanol and open-circuit conditions, offers comparable performance to the proprietary Keysight system. Moreover, results are also comparable to measurements at 2.45 GHz documented in the literature. Being the in-house system suitable for portable setups as reported in the literature, this study shows that measurement of dielectric properties of tissue can be performed even during the thermal ablation procedure.

11:50 ***Temperature-dependent Dielectric Properties of 0.1N NaCl as Validation Data for Dielectric Measurements Systems***

Lourdes Farrugia, Julian Bonello, Jessica Falzon and Charles Sammut (University of Malta, Malta)

The dielectric properties of a material describe its storage and dissipation of energy when exposed to electromagnetic radiation. In this study permittivity measurements were performed on 0.1N NaCl from 0.5 - 40.8 GHz and from a temperature of 25 ºC to 52 ºC. This study was done so as to validate the coaxial probe technique. To date, the studies published on NaCl are limited to 35 ºC and do not exceed the frequency of 20 GHz. This study extends both the frequency and temperature range investigated, this is of particular interest due to the use of microwave thermal ablation. The dielectric parameters for 0.1N NaCl have been plotted as a function of frequency and temperature. The results obtained were also compared to those previously published were possible and this yielded a good agreement. The proposed method is not only useful for standard liquids but also for lossy materials such as biological matter.

12:10 ***Ultra-Wideband Temperature Dependent Dielectric Spectroscopy of Blood in the Microwave Frequency Range***

Sebastian Ley and Susanne Schilling (Technische Universität Ilmenau, Germany); Ondrej Fiser, Jr. and Jan Vrba (Czech Technical University, Czech Republic); Jürgen Sachs and Marko Helbig (Technische Universität Ilmenau, Germany)

The knowledge of temperature dependent dielectric properties of biological tissue in the microwave frequency range is crucial for medical applications such as microwave temperature monitoring during oncological treatments. This paper deals with temperature dependent dielectric spectroscopy of blood by means of ultra-wideband sensing. We present the results of relative permittivity and conductivity of blood without agents and blood with heparin in the frequency range of 0.5 GHz up to 7 GHz and in the temperature range between 30°C and 50°C. The measurements show that the addition of heparin does not affect the dielectric properties in the considered frequency and temperature range. Furthermore, the measurements are compatible with the few data reported in the literature.

Wednesday, April 3 10:50 - 12:30

CS42 Plasma Ant: CS42 Plasma Antennas

TOP

Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Mohamed Himdi (Université de Rennes 1, France), Olivier Pascal (Université de Toulouse - UPS INPT CNRS, France)

10:50 ***Towards Antenna Miniaturization Using Plasma***

Vincent Laquerbe (CNES, France); Romain Pascaud (Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO), Université de Toulouse, France); Thierry Callegari, Laurent Liard and Olivier Pascal (Université de Toulouse - UPS INPT CNRS, France)

A new concept of plasma-based electrically small antenna (ESA) is proposed in this paper. It relies on the excitation of a localized surface plasmon resonance in a subwavelength hemispherical plasma discharge. Preliminary measurement results exhibit antenna resonance and radiation enhancement in the low UHF band despite the electrically small size of the antenna (lambda/9 at 300 MHz).

11:10 ***Plasma Antenna Design for RCS Reduction***

Jusoh Tajudin Mohd Taufik (IETR, University of Rennes 1 & Faculty of Engineering, National Defence University of Malaysia, France); Mohamed Himdi (Université de Rennes 1, France); Olivier Lafond (IETR, France); Franck Colombel (Université de Rennes 1, France)
This paper deals with the use of reconfigurable plasma reflector antenna to demonstrate the reduction of the RCS of such antenna by de-activating the plasma (Compact fluorescent lamp). It is a big advantage if we compare with a similar reflector antenna using metallic antenna elements, because the reflectors using plasma antenna elements can become furtive.

11:30 ***Magnetic Imaging Resolution and Positron Emission Tomography Using Plasma Antennas***

Theodore Anderson (Haleakala Research and Development, USA)
This paper shows various experiments that were done to show advantages of using plasma antennas instead of metal antennas in magnetic resonance imaging (MRI) and positron emission tomography (PET) in conjunction with magnetic resonance imaging. The metal antenna coils were removed from an MRI machine and replaced by plasma antennas in the form of simple fluorescent tubes. The first in vivo imaging was done with plasma antennas in an MRI machine.

11:50 ***Antenna Beam Focusing and Steering with Refraction Through a Plasma***

Theodore Anderson (Haleakala Research and Development, USA)
In this paper experimental results are presented to steer and focus an antenna beam using physics of refraction of antenna beams through plasma. These results have been incorporated in a smart plasma antenna design.

12:10 ***Reconfigurable Slotted Cylindrical Waveguide and Coaxial Array Antenna Using Plasma***

Oumar Barro (Institute of Electronics and Telecommunications of Rennes, (IETR) University of Rennes 1, France); Mohamed Himdi (Université de Rennes 1, France); Hamsakutty Vettikalladi (King Saud University, Saudi Arabia)
A novel reconfigurable cylindrical slotted waveguide antenna associated with plasma tube is proposed. The performance of the reconfigurable system is observed in terms of S21, maximum realized gain, radiation patterns and total efficiency. It is shown that by switching ON or OFF the fluorescent lamp, we can change the antenna operating mode. When the plasma is OFF, we have the waveguide behavior with a cutoff frequency around 2.5 GHz and when the plasma is ON, the behavior become 50 ohms coaxial line. By adding slots, we obtain reconfigurable antenna working at 4 GHz and 1 GHz. The main idea is to obtain reconfigurable slotted cylindrical waveguide and coaxial array antenna using plasma.

CS5 Prop for UAVs: CS5 Propagation for unmanned aerial vehicles (UAVs)

TOP

Cellular Communications / Convened Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany), Fernando Pérez-Fontán (University of Vigo, Spain)

10:50 ***UAV Channel Models: Review and Future Research***

David W Matolak (University of South Carolina, USA); Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany)
The use of unmanned aerial vehicles (UAVs), also known as unmanned aircraft systems (UAS) or drones, is growing, for an expanding variety of applications, and this growth is expected to continue for the foreseeable future. Since these platforms are not only mobile, but can ascend to significant altitudes above the earth, channel models for ground to/from UAVs are distinct from typical terrestrial channel models. Because of the importance of wireless channel models for communications (and navigation, surveillance), work on UAV-ground channels has seen much recent attention. In this paper we provide a review of the UAV wireless channel. We compare with other types of channels, and review some measurements and current models. We finish with a discussion of future work on UAV channel modeling.

11:10 ***Angular Distribution of Cellular Signals for UAVs in Urban and Rural Scenarios***

Tomasz Izydorczyk, Fernando M. L. Tavares, Gilberto Berardinelli, Mădălina Bucur and Preben Mogensen (Aalborg University, Denmark)
Spatial channel characterization of a cellular Unmanned Aerial Vehicle (UAV) Air-to-Ground (AG) communication link is a vital step to understand the potential of beamforming in the take-off zone, when a UAV flies in the vicinity of other objects. In this paper, we evaluate the variation of mean Angle of Arrival (AoA) and Angular Spread (AS) with height based on the experimental measurements using live Long Term Evolution (LTE) networks. The LTE signals are recorded at different heights from a ground level up to 40 m in rural and urban environments. Space-Alternating Generalized Expectation-Maximization (SAGE) algorithm is used for the estimation of the angular parameters. Results show similar mean AoA at different heights, with less than 55 degrees deviation in urban environment and no more than 20 degrees change in rural scenarios. Observed AS is reduced to less than 30 degrees at increasing heights as the Line of Sight (LoS) propagation becomes dominant. However the comparison between urban and rural environments clearly indicates the presence of relevant multipath components in the urban scenarios even 20 m above the rooftops level.

11:30 ***Narrowband Validation of a Deterministic Model inUAV Scenarios***

Fernando Pérez-Fontán (University of Vigo, Spain); Pavel Valtr (Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic); Pavel Pechac and Milan Kvicera (Czech Technical University in Prague, Czech Republic); Ioana Gulie (Airbus, Germany)
We present a partial validation of a deterministic tool initially oriented to wideband satellite navigation channel modeling. We try to reproduce the shadowing effects in a low elevation link emulating the conditions encountered in UAV scenarios.

11:50 ***Path Loss Characteristics for UAV-to-Ground Wireless Channels***

George Tsoulos and Georgia E. Athanasiadou (University of Peloponnese, Greece)
UAVs have been proposed in the context of 5G cellular networks to act as flying basestations or relays in order to offer wireless services to underserved areas or support problematic cases such as flash crowd situations. This paper provides path loss characteristics for the air-to-ground radio channel using data produced with deterministic propagation modelling for an urban operational scenario. The presented analysis separates LOS and NLOS conditions and calculates the path loss exponent for different UAV heights, as well as the std of the distance-dependent path loss model and the ray tracing predictions.

12:10 ***Diffracion Path Losses Measurements for Low Altitude UAVs***

Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); César Calvo Ramírez (Universidad Politécnica de Madrid, Spain)
The maximum altitude of flight for medium and small size UAVs is limited to a maximum height of 120m. Therefore these vehicles frequently fly close to the rooftop of buildings in urban or semi-urban environments, while the control station is 1-2km away. On this conditions, the low flying height moderately affects the propagation by introducing additional losses by diffraction. In this paper we present a detailed analysis of the additional diffraction losses for UAV fliyin on semiurban environment. Diffraction losses are based on the ITU for the normal flight conditions of UAVs. Measurements have been made with a medium-sized UAV in a suburban environment at two frequencies: 440Mhz and 1000Mhz, under normal flight conditions with control station on the top of a building. The results allow to analyze the accuracy of the diffraction model and the additional losses when the UAV flies near the roofs of the buildings.

C_A04 Cell ant: C_A04 Cellular communication antennas

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Malgorzata Celuch (QWED, Poland), Brett Walkenhorst (NSI-MI Technologies, USA)

10:50 ***Novel Regime for Antenna Array Oscillators Based on Exceptional Point of Degeneracy***

Ahmed F. Abdelshafy and Tarek Mealy (University of California, Irvine, USA); Hamidreza Kazemi (University of California Irvine, USA); Mohamed A. K. Othman and Filippo Capolino (University of California, Irvine, USA)
We demonstrate a new regime of operation to conceive radiating array oscillators. This regime based on the dispersion engineering of coupled transmission lines (CTLs) utilizing an exceptional point of degeneracy (EPD), which represents the coalescence of multiple eigenmodes. We propose the "gain and loss balance" regime for structures subject to significant radiation losses to enable an innovative regime for a class of coherent EPD-based radiating oscillators with a stable oscillation frequency. Moreover, we show that this new class of radiating oscillators has a promising threshold trend scales with the length of the structure. This multipurpose EPD concept has potential applications in high power efficiency oscillators and high-power radiation.

11:10 ***Millimeter-Wave Channel Characterization in Large Hall Scenario at the 10 and 28 GHz Bands***

Guojin Zhang (Aalborg University, Denmark); Panawit Hanpinitsak (Tokyo Institute of Technology, Japan); Xuesong Cai and Wei Fan (Aalborg University, Denmark); Kentaro Saito and Jun-ichi Takada (Tokyo Institute of Technology, Japan); Gert Pedersen (Aalborg University, Denmark)
This paper presents the characteristics of the mm-wave propagation channel in hall scenario at the frequency bands of 9-11 GHz and 27-29 GHz. The spherical propagation parameters, i.e. delay, azimuth, elevation, source distance, and complex amplitude are estimated by the high-resolution parameter estimation (HRPE) algorithm. Based on the results, the channel characteristics, e.g. path loss, delay spread, and angle spread are analyzed for different mm-wave bands. The results reveal that the line of sight and specular components are dominant in such large size scenario at 9-11 GHz and 27-29 GHz bands, and little differences in the characteristics between the two bands can be observed.

11:30 ***Test Environments for 5G Millimeter-Wave Devices***

Brett Walkenhorst (NSI-MI Technologies, USA)

As 5G systems are developed and deployed, the RF devices comprising these networks require various types of tests at multiple stages of the design and manufacturing processes. The use of millimeter-wave frequencies and massive MIMO, a combination of technologies intended to ensure sufficient bandwidth and SNR to support massive data throughput, is leading to unprecedented levels of integration of antenna arrays and transceivers. Testing these highly integrated devices is becoming increasingly complex and challenging. In this paper, we investigate various test environments for 5G over-the-air (OTA) testing including far-field, compact range, and near-field chambers. We examine the advantages and disadvantages of each for measuring various over-the-air (OTA) test metrics. This paper offers a high-level trade study by broadly analyzing cost, path loss, and applicability of each environment to different types of OTA tests.

11:50 ***Reconfigurable Split Ring Resonators for Spatial Modulation Communications***

Abdelwaheb Ourir (Institut Langevin ESPCI Paris CNRS, France); Julien de Rosny (Institut Langevin, ESPCI Paris, CNRS, France); Kammel Rachedi (Institut Langevin ESPCI Paris CNRS, France); Dinh-Thuy Phan-Huy (Orange-France Telecom, France)

Very recently, a new concept of low-power consumption and high datarate wireless communication systems appeared. The so-called Spatial Modulation MIMO (SM-MIMO) is based on the ability of the emitter to generate several radiation patterns. We develop a small reconfigurable antenna based on split ring resonators for SM-MIMO. This antenna is able to deliver 8 different radiation patterns at 2.45 GHz. For all of them, a good impedance matching (S11 < - 10 dB) is obtained. The spatial diversity is a key point of SMMIMO. For this purpose, the complex inter-correlation matrix bwteen the 8 states is computed and analyzed. Regarding the SM-MIMO, the bit error rate is assessed versus the Signal to Noise Ratio in a Non-Line-Of-Sight (NLOS) configuration.

12:10 ***Broadband True Time Delay Microwave Photonic Beamformer for Phased Array Antennas***

Ilka Visscher, Chris Roeloffzen, Caterina Taddei, Marcel Hoekman, Lennart Wevers, Robert Grootjans, Paul Kapteijn, Dimitri Geskus, Andrea Alippi, Ronald Dekker, Ruud Oldenbeuving, Jörn Epping, Roelof Bernardus Timens, Edwin Klein, Arne Leinse, Paul van Dijk and René Heideman (LioniX International BV, The Netherlands)

In this paper, we present results on true time delay-based, broadband, and continuously tunable photonic beamforming modules for phased array antennas. The RF beamforming module is based on hybrid optical integration of TriPleX and InP chips. We present two types of analog photonic links (APLs) to achieve true time delay (TTD) beamforming. The parameters of the individual integrated components and their impact on the APL are discussed together with the theory for the two APLs. The measurement results of two 1x4 TTD beamforming architectures are presented: one switched-based and one ring resonator-based.

L_P01 Radar LocSens: L_P01 Radar, Localisation, and Sensing

TOP

Localization & Connected Objects / Regular Session / Propagation

Room: Oral Sessions: S4-C - Kielce

Chairs: Herve Aubert (LAAS, France), Wout Joseph (Ghent University/IMEC, Belgium)

10:50 ***A Maximum Likelihood Location Estimator for Non-Line of Sight Geolocation of Radio Emitters***

Benjamin Gear (Defence Science and Technology Laboratory & University of Bristol, United Kingdom (Great Britain)); Evangelos Mellios, Andrew Nix and Joe McGeehan (University of Bristol, United Kingdom (Great Britain))

We propose a novel Maximum Likelihood (ML) location estimator for use in dense urban environments that uniquely exploits the scattering environment geometry in order to mitigate the need for Line of Sight (LOS) paths. The estimator is derived and a method for calculating a numerical approximation is presented. A simple scattering model is used to assess the performance of the algorithm. Within a 400 m by 400 m search area a mean estimation error of 45 m to 133 m is achieved, depending on the assumed parameters of the simulated propagation environment.

11:10 ***Joint Received Signal Strength, Angle-of-Arrival, and Time-of-Flight Positioning***

David Plets (Ghent University - imec, Belgium); Wouter Deprez and Jens Trogh (Ghent University, Belgium); Luc Martens (Ghent University - imec, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper presents a software positioning framework that is able to jointly use measured values of three parameters: the received signal strength, the angle-of-arrival, and the time-of-flight of the wireless signals. Based on experimentally determined measurement accuracies of these three parameters, results of a realistic simulation scenario are presented. It is shown that for the given configuration, angle-of-arrival and received signal strength measurements benefit from a hybrid system that combines both. Thanks to their higher accuracy, time-of-flight systems perform significantly better, and obtain less added value from a combination with the other two parameters.

11:30 ***UHF-RFID Localization: The Problem of Antenna Phase Center in Phase-based Methods***

Alice Buffi (University of Pisa, Italy); Daniele Fontanelli, David Macii and Valerio Magnago (University of Trento, Italy); Andrea Motroni, Paolo Nepa and Bernardo Tellini (University of Pisa, Italy)

The correct determination of the antenna phase center is a key point when performing UHF-RFID localization through a phase-based method. In this paper, we investigate the effect of a wrong knowledge on the reader antenna phase center in phase-based methods exploiting the relative motion of the reader antenna with respect to the stationary tags through a Synthetic Aperture Radar approach. An experimental analysis is carried out in a real scenario with the reader antenna attached on a robotic-wheeled walker.

11:50 ***Measurement Qualification Metrics for Passive HF Geolocation***

Ankit Jain, Pascal Pagani, Rolland Fleury, Michel Ney and Patrice Pajusco (IMT Atlantique, France)

Passive HF geolocation methods can be used to extract the location of an unknown transmitter in the range of one-hop HF links through a synchronized time difference of arrival (TDoA) network. This paper aims to highlight that a measurement can be qualified with respect to the different parameters available at the reception sites in the context of passive HF geolocation. In particular, a qualified measurement could be used to estimate the transmitter location whereas unqualified measurement could be discarded which, if processed, would result in a totally incorrect estimate of transmitter location. HF receiver design and the installed receiver network to synchronously capture HF radio signals are presented. Measurements from different transmitters are analyzed in terms of different estimated measurement metrics with the purpose of measurement qualification or elimination. Specifically, data reduction is achieved based on the analysis of the estimated TDoA's by exploiting the assumed coherence of collected measurements over time.

12:10 ***Application of Evolutionary Approach for Multi-objective Improvement of Indoor Access Point Placement***

Piotr Korbel and Slawomir Hausman (Lodz University of Technology, Poland); Paolo Di Barba (University of Pavia, Italy)

The paper presents the application of a multi-objective evolutionary computing implementation, called P-EStra, to the improvement of deployment of access nodes/radio beacons of both indoor wireless access and positioning. In the paper, new formulations of objective function components are proposed for simultaneous improvement of service coverage and indoor positioning accuracy. One objective function component uses path loss to assess the service coverage, while the other uses a GDOP (HDOP) - Geometric (Horizontal) Dilution of Precision factor to assess the location estimation precision. Simulation results illustrating performance of the proposed method are shown an discussed.

R_P20 Radar Localis: R_P20 P20 Radar, localisation, and sensing

TOP

Radars / Regular Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Youngwook Kim (California State University, Fresno, USA), Okan Yurduseven (NASA Jet Propulsion Laboratory, California Institute of Technology & Duke University, USA)

10:50 ***Classification of Micro-Doppler Signatures Measured by Doppler Radar Through Transfer Learning***

Ibrahim Alnujaim (California State University, Fresno, USA); Daegun Oh (DGIST, Korea); Ikmo Park (Ajou University, Korea); Youngwook Kim (California State University, Fresno, USA)

In this paper, we investigate the feasibility of using transfer learning for the classification of micro-Doppler signatures measured by Doppler radar. A target with a non-grid body generates micro-Doppler signatures when measured by Doppler radar, which serve as an important feature for classification. However, the radar dataset is, in general, insufficient because of the high cost of its measurements. To overcome the problem of data deficiency, we propose transfer learning, which involves borrowing a classifier that has already been trained for other applications. In particular, we borrow a network trained for other micro-Doppler spectrograms rather than optical images. For the construction of the training dataset, we augment said data through generative adversarial networks. This idea is verified using human activity data measured by Doppler radar.

11:10 ***A Compact Mini-InSAR System for DSM Generation***

Maosheng Xiang, Jinsong Chong and Bingnan Wang (Institute of Electronics, Chinese Academy of Sciences, P.R. China); Xikai Fu (Institute of Electronics, Chinese Academy of Sciences & University of Chinese Academy of Sciences, P.R. China); Xiaoning Hu (Institute of Electronics, Chinese Academy of Sciences, P.R. China)

Mini-InSAR is a miniature interferometric synthetic aperture radar (InSAR) with small-volume, light-weight and cost-effective characteristics. It is a combination of frequency modulation continuous wave technology (FMCW) and InSAR. It not only has the capability of topographic mapping with high accuracy under all-day, all-weather conditions, but also has small-volume, light-weight

and cost-effective advantages due to large time bandwidth product and low peak power of its transmitted signal. The National Key Laboratory of Microwave Image Technology, Institute of Electronics, Chinese Academy of Sciences has accomplished system design, implementation and several flight experiments of Ka and Ku-band Mini-InSAR. This manuscript briefly describes system configuration, signal processing, preliminary results and future developments of our mini-InSAR system.

11:30 ***Interference Analysis Between LTE-2600 MHz Networks and Air Traffic Control Radars in S-Band***

Nektarios Moraitis (National Technical University of Athens & Institute of Communications and Computers Systems, Greece); Konstantina Nikita (National Technical University of Athens, Greece)

This paper assesses the potential in-band (IB) and out-of-band (OOB) interference from a terrestrial Long Term Evolution (LTE) network, operating at 2600 MHz to an Air Traffic Control (ATC) radar in S-band. The interference analysis is based on both measurements and simulations, incorporating line-of sight (LOS) and non-LOS (NLOS) scenarios. The results reveal that in LOS cases the radar is exposed to severe IB, and possible OOB interference, from an LTE transmitter being 8.4 km apart. This could create serious complications in the design, and deployment procedure of an LTE network, unless robust mitigation techniques are considered. Finally, in NLOS conditions, no harmful interference is detected.

11:50 ***Highly Integrated Dual-Band Dual-Polarized Antenna Tile for SAR Applications***

Emilio Arnieri and Luigi Boccia (University of Calabria, Italy); G. Amendola (Universita della Calabria, Italy); Srdjan Glisic (Silicon Radar, Italy); Chun-Xu Mao and Steven Gao (University of Kent, United Kingdom (Great Britain)); Tobias Rommel (German Aerospace Centre (DLR), Germany); Piotr Penkala (Evatronix S.A. Bielsko-Biała, Italy); Milos Krstic (IHP, Germany); Uroschanit Yodprasit (Silicon Radar GmbH, Germany); Oliver Schrape (IHP, Germany); Marwan Younis (German Aerospace Center (DLR), Germany)

The experimental assessment of a highly integrated dual-band (9.6 and 35.75 GHz) dual-polarized antenna tile designed for Synthetic Aperture Radar (SAR) Digital Beam Forming (DBF) satellite applications is presented. Antennas, transitions and down-conversion chips are integrated in the same board fabricated using a customized 15 layer PCB. The experimental assessment proves the validity of the proposed manufacturing and integration approaches, a good agreement between the performance of the individual blocks and of the integrated system has been demonstrated.

12:10 ***Phase Noise Influence on Radar Signal Focusing and SAR Tomography***

Harkati Lekhmissi (University of Rennes 1, France); Stéphane Avrillon (Université de Rennes 1, France); Laurent Ferro-Famil (University of Rennes 1, France)

This paper studies the influence of phase noise on radar signal focusing and SAR tomography. Firstly, we create and add phase noise to simulated data for 1D focusing. A quasi-linear degradation of resolution is observed for 1 kHz phase noise level higher than -22 dBc/Hz. Secondly, phase noise is added to multi channel measured data showing that 1 kHz phase noise level higher than -60 dBc/Hz affects SAR tomographic reconstruction quality. Index Terms-Phase noise, SAR focusing, SAR Tomography.

MT_P11 Meas techn: MT_P11 Measurement techniques

TOP

Methods & Tools / Regular Session / Propagation

Room: Oral Sessions: G2- Opole

Chairs: María Elena de Cos Gómez (Universidad de Oviedo, Spain), Fernando Las-Heras (Universidad de Oviedo, Spain)

10:50 ***Fast Phased Array Antenna Calibration Incorporating with a Far-field Radiation Measurement System***

Hsi-Tseng Chou and Jake W. Liu (National Taiwan University, Taiwan); Wen-Jiao Liao (National Taiwan University of Science and Technology, Taiwan)

This paper presents an efficient procedure to calibrate phased array antennas by using a far-field antenna radiation measurement system such as compact antenna test range (CATR). The proposed method takes advantage of the fast electronically switching property of digital phase shifters, and incorporates discrete Fourier transform (DFT) technique to find the phase and amplitude errors caused by channel mismatch and distortion. As a result, the mechanical scan of radiation measurement can be avoided by using a single point measurement over the antenna under test (AUT). The calibration algorithm is discussed and some preliminary simulation results are demonstrated to validate the proposed method.

11:10 ***A Real-Time Propagation Channel Sounder for 5G Applications***

Jean-Marc Conrat (Orange Labs, France)

this paper describes a wideband radio channel sounder. Such a device is able to measure the complex time-variant impulse response of the propagation channel. The impulse response is obtained by inversion of an optimal multi-sine sequence with flat spectrum and low crest factor. In standard configuration, this device is able to measure the propagation channel impulse response with a maximum bandwidth of 800 MHz in the DC-30 GHz frequency range fulfilling 5G requirements especially for millimeterwave frequencies. The receiver digital part is based on a PCIe 3 Gs/s 12-bit digitizer implementing efficient data streaming functions. The measurement software is a C/C++ Windows 10 application and uses advanced optimization technologies such as vectorization or multi-threading making possible real-time operations. The simultaneous transfer function on two channels is acquired, processed and saved in less than 100 µs. RF and digital parts have been simplified in order to reduce the form factor, the weight, the power consumption and maintenance issues.

11:30 ***Monostatic and Bistatic Measurements of Metasurfaces on Anechoic Chamber and a Comparison with Electromagnetic Simulations***

Humberto Fernandez Alvarez (University of Oviedo, Spain); María Elena de Cos Gómez and Fernando Las-Heras (Universidad de Oviedo, Spain)

The paper will be focused on experimentally characterize a metasurface absorber under both a quasi-monostatic and a bistatic set-up configuration. The aim is to introduce most of the difficulties that a researcher may encounter, when characterizing this finite structure and compare them with the simulation, which assumes the metasurface as infinite. Moreover, the limitations of both the quasi-monostatic and bistatic measurements will be introduced, as well as a comparison between them. In addition, several guidelines to retrieve precise measurements are provided and applied to the presented set-ups. These recommendations will be of interest for many authors who want to experimentally characterize their metasurfaces. The latter will be corroborated through the high-quality and precise measurements obtained and shown throughout this paper.

11:50 ***Impact of Network Scenarios on Quality ofExperience Using TRIANGLE Testbed***

Hua Wang and German Corrales Madueno (Keysight Technologies, Denmark); Marek Rohr (Keysight Technologies Denmark, Denmark); Michael Dieudonné (Keysight Technologies, Belgium); Carlos Cárdenas Angelat, Pablo Aurelio Romero Hierro and Janie Baños Polglase (DEKRA, Spain)

The TRIANGLE project aims at building a 5G testing framework that can allow end-to-end Quality of Experience (QoE) evaluation for new mobile applications and devices. An important task in building such a testbed is the definition of network scenarios which should cover as many user conditions as possible. This paper presents the general testbed framework and the identified network scenarios. An analysis of the number of iterations needed to achieve stable results is carried out, which shows the exact number depends on the network scenario and the traffic profile. A case study of a content streaming application (Exoplayer) with focus on the user experience domain is presented. The measurement results show that the network scenario has significant impact on the measured Key Performance Indicators (KPIs), which sheds some light on how propagation or antenna configurations will influence the overall application/service performance.

12:10 ***Antenna-on-Chip Radiation Pattern Characterization - Analysis of Different Approaches***

Qiang Liu, Ulf Johannsen, Martijn van Beurden and A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

Millimeter-wave antenna measurements severely rely on the use of on-wafer probes. For an Antenna-on-chip (AoC), due to the tiny size of the chip (1~2 mm2), the radiation pattern will still be influenced when the probe tip is near the AoC under test (AUT). In addition, the edges of ground plane, the probe body, and the large holder will diffract the radiated fields and cause unexpected results. We have investigated how the probe and the test environment influence the radiation pattern by using a step-by-step approach to analyze the contribution each of the interfering sources. This analysis together with an experimental verification shows that an accurate radiation pattern of AoCs is difficult to characterize using existing probe-fed measurement strategies. To eliminate the large probe tip and body, a system-level approach could be used where the frequency generator is integrated on-chip. Another possible solution for an antenna designer is the bonding wire solution, which is low cost and easy to fabricate. The key rule of the design is that the location of the bond-wires needs to be perpendicular to the E-plane of the AUT.

Wednesday, April 3 13:30 - 15:00

Poster_04: Poster_04

TOP

Localization & Connected Objects / Poster Session / Antennas

Room: Poster Sessions: P1 - Odra

Chairs: Slawomir Hausman (Lodz University of Technology, Poland), Adam Narbudowicz (Wroclaw University of Science and Technology, Poland & TU Dublin, Ireland)

Poster_04.1 ***Ultra-Thin Compact Flexible Antenna for IoT Applications***

María Elena de Cos Gómez (Universidad de Oviedo, Spain); Humberto Fernandez Alvarez (University of Oviedo, Spain); Cebrián García González and Blas Puerto Valcarce (Fundación PRODINTEC, Spain); John Olenick (ENrG-Inc, USA); Fernando Las-Heras (Universidad de Oviedo, Spain)

A CPW-Fed slot monopole antenna suitable for IoT applications is designed using three different dielectric substrates: a novel flexible ceramic (ENrG Thin E-Strate), the rigid ARLON 25N and flexible Polypropylene (PP). The required dimensions and the simulation results concerning impedance matching and radiation properties are compared. Prototypes of the optimized ultra-thin

compact flexible antenna, based on the novel ENrG Thin E-Strate, are fabricated using two different metallization techniques: electrotextile based and inkject printing. The measurement results regarding return losses for the fabricated prototypes using both procedures are then compared and also with the simulation ones to draw some conclusions.

Poster_04.2 ***Characterization of an Implanted Antenna Inside a 3D Printed Multilayer Hip Phantom***

Erdem Cil and Sema Dumanli (Bogazici University, Turkey)

A Cavity Backed Slot (CBS) antenna is designed to operate inside the human body for the application to smart hip implants at the 2.4 GHz ISM band. A multilayered hip phantom is developed using 3D printed hip and bone models filled with muscle and bone mimicking liquids. A hip stem and a ceramic head by Corail are attached to the femur and the hip bone respectively. The antenna is located at one of the vertices of the metallic stem. The hip phantom is fixed on a turntable and the antenna's performance is measured inside a 1x1x2m portable anechoic chamber. The paper details the measurement set-up and shows that the frequency response and the transmission response of the antenna are within the desired range.

Poster_04.3 ***A Novel Compact Microstrip Antenna Embedded with Magneto-Dielectric Ferrite Materials for 433 MHz Band Applications***

Xu Wu and Zongliang Zheng (Southwest Jiaotong University, P.R. China)

In this paper, a novel and compact microstrip patch antenna with relatively high gain is proposed for ISM 433 MHz applications. To realize the miniaturization of the antenna, patch and ground slots are utilized in this paper. For gain enhancement, this paper uses folded metal sheets to reduce cross-polarization, and this method maintains the advantage of low profile of microstrip antenna. Furthermore, a pair of novel magneto-dielectric ferrite bars which have high permittivity and permeability are embedded into substrate to further reduce antenna size and modify antenna performance. A parametric study on the effects of the permeability of ferrite, biased magnetic field strength, ferrite size and height of metal sheets are presented. The proposed antenna has a bandwidth of 2.1 MHz, gain of 1.3 dBi, and an omni-directional radiation pattern. The total size of the proposed antenna is 70 mm × 75 mm × 15 mm.

Poster_04.4 ***A Retro-directive Array Antenna with 3-State Phase Shifter for Microwave Power Transfer***

Hye-Won Jo (Korean Advanced Institute of Science and Technology, Korea); In-June Hwang (Korea Advanced Institute of Science and Technology(KAIST), Korea); Ju-Ik Oh, ByungKuon Ahn and Jong-Won Yu (KAIST, Korea)

In microwave power transfer system, the large array antennas are necessary and should apply the retro-directive beamforming which is effective in Fresnel region. The retrodirective array antennas requires not only hundreds or thousands antennas but also RF chains. In this paper, for decreasing the cost and complexity of large array antennas, the focusing effect of retro-directive array antenna using low-bit phase shifter is analyzed. Also, a 3-state phase shifter is proposed for effective focusing effect. For testing the proposed antenna, the 16x1 retrodirective array antenna as a test-bed was implemented, and the power transfer were carried out.

Poster_04.5 ***On-Ground UWB Antenna Mounted on External Wind Turbine Blade Surface for Deflection Tracking***

Shuai Zhang (Aalborg University, Denmark); Ondřej Franek (Aalborg University & APMS Section, Denmark); Gert Pedersen (Aalborg University, Denmark)

In this paper, a low-profile UWB antenna is proposed which is mountable on the external surface of the blade. The antenna covers the UWB band of 3.1-4.9 GHz with the endfire radiation pattern. Different locations of the antenna on the external surface are investigated. Trailing edge location is a good alternative to the leading edge when placing the UWB antenna externally. Full-blade measurements are carried out to study the UWB pulse quality. It is found that in the applications, the root antenna over the downwind surface and the external tip antenna on the trailing edge should be utilized in order to realize high-quality UWB pluses in different deflections and satisfy the application requirement of air dynamics.

Poster_04.6 ***Polarization Characteristics of Flat Cavity Resonant Antenna***

Nikolay Voytovich and Viktor Bukharin (South Ural State University, Russia)

Polarization properties of the original Cavity Resonant Antenna are investigated in this abstract. The antenna contains two interconnected volume resonators - a cylindrical resonator with a partially transparent (radiating) flat wall and a coaxial-slot resonator located in it. The main characteristics of the antenna in the main planes are given. It is shown that the level of cross-polarization radiation does not exceed minus 50 dB within the main pattern lobe.

Poster_04.7 ***Design of a Microstrip-based Wideband Wearable Antenna for the 2 to 3 GHz Band***

Ezzaty Faridah Nor Hussin (Universiti Malaysia Perlis, Malaysia); Ping Jack Soh (Universiti Malaysia Perlis (UniMAP) & Katholieke Universiteit Leuven, Malaysia); Mohd Jamlos (Manager, Malaysia); Herwansyah bin Lago (Fakulti Kejuruteraan, Universiti Malaysia Sabah Jalan UMS, Kota Kinabalu, Sabah, Malaysia); Azremi Abdullah Al-Hadi (University Malaysia Perlis, Malaysia); Qassim Abdullahi and Dimitris E. Anagnostou (Heriot Watt University, United Kingdom (Great Britain)); Symon K. Podilchak (Heriot-Watt University, United Kingdom (Great Britain))

The design procedure for a wideband wearable antenna made fully using textiles based on the microstrip topology is presented. The antenna operates within the 2 to 3 GHz band with a fractional bandwidth of 51 % and low back radiation towards the body. This ensured its minimal interaction with human users when worn while also reducing electromagnetic power absorption into human tissue. The narrowband characteristics of the microstrip antenna, which is the basis of the design, is alleviated by integrating several broadbanding techniques: multi-resonance overlapping, increasing substrate thickness, addition of slots and parasitic patches, and finally, impedance tuning using a staircase-like structure. The levels of forward and back radiation are assessed and the antenna features 17 dB front-to-back ratio and 3.5 dBi average gain throughout its operating band.

Poster_04.8 ***Passive UHF RFID Yarn for Relative Humidity Sensing Application***

Santasri Koley (University Claude Bernard Lyon 1, France); Sofia Benouakta (Université Claude Bernard Lyon 1, France); Florin Hutu (Univ Lyon, INSA Lyon, Inria, CITI, France); Yvan Duroc (University Claude-Bernard Lyon 1, France)

In this paper, a passive ultra-high frequency (UHF) radio frequency identification (RFID) humidity sensor tag inside a slenderly yarn is presented. The sensor tag antenna is designed within a very small diameter textile wire of less than 0.6 mm. The proposed solution is based on both theoretical analysis and detailed simulation results in coherence with theory. The tag system consists of capacitive based sensor where polyimide is used as a sensing material to adapt the change with relative humidity [5]. Any variation of capacitive values will change the response of the tag. More precisely, the resonance frequency of the tag is shifted from 864.5 MHz to 867.3 MHz covering European UHF RFID frequency band when the relative humidity (HR) is varying from 35% to 95%.

Poster_04.9 ***A Low Cost Circular Polarized Antenna Array for GPS Receivers***

Tamer Elshikh (Ain-shams University, Egypt); Ahmed Sayed (Ain Shams University, Egypt); Alla Eid (Alexandria University, Egypt); Ahmed Alieldin (University of Liverpool, United Kingdom (Great Britain))

This paper proposes a new design of a circular polarized antenna for GPS applications. The proposed antenna is a circularly polarized, asymmetric-slit square microstrip patch with a proximity coupled feed to offer a broadband. Circular polarization is achieved by slightly varying the circumferences of the slits along one of the patch diagonals to improve the axial ratio bandwidth and to miniaturize the antenna size (25% size reduction). To improve the antenna gain, the design has been amended to form an antenna array. The results demonstrate that the antenna array has bandwidths of 80 MHz and 22 MHz for impedance matching and axial ratio respectively. The realized gain of the antenna array is about 10.8 dBic which makes the proposed design a good candidate for GPS applications.

Poster_04.10 ***A Hybrid BLE/UWB Localization Technique with Automatic Radio Map Creation***

Marcin Kolakowski (Institute of Radioelectronics and Multimedia Technology, Warsaw University of Technology, Poland)

Localization systems intended for home use by people with mild cognitive impairment should comply specific requirements. They should provide the users with sub-meter accuracy allowing to analyze patient's movement trajectory and be energy effective, so the devices do not need frequent charging. Such requirements could be satisfied by employing a a hybrid positioning system combining accurate UWB with energy efficient Bluetooth Low Energy (BLE) technology. In the paper a concept of such solution is presented and experimentally verified. In the proposed system, user's location is derived using BLE fingerprinting. Radiomap utilized by the algorithm is created automatically during system operation with the support of UWB subsystem. Such approach allows to repeat system calibration as often as possible, which raises systems resistance to environmental changes.

Poster_04.11 ***Strain Reliability of Embroidered Passive UHF RFID Tags on 3D-printed Substrates***

Zahangir Khan (Tampere University, Finland); Muhammad Rizwan (Tampere University of Technology, Finland); Riku Rusanen (Prenta Oy, Finland); Leena Ukkonen and Johanna Virkki (Tampere University of Technology, Finland)

Flexible electronics is an emerging field where the electronic components, antennas, and interconnections can endure significant mechanical stresses. This paper presents the fabrication and strain reliability evaluation of embroidered passive UHF RFID tags on 3D-printed (NinjaFlex) substrates. Based on the achieved results, these wireless platforms can withstand increases up to 14 % in length and remain functional. These preliminary results are promising, considering the current trend towards flexible and stretchable electronics structures.

Poster_04.12 ***ILS Glide Slope Antenna Array for Airfields with a High Level of Snow Cover***

Ekaterina Iungaitis (Chelyabinsk Radio Plant Polyot, Russia); Nikolay Voytovich, Aleksey V. Ershov, Boris V. Zhdanov and Andrei V. Zotov (South Ural State University, Russia)

The paper presents antenna arrays for a glide slope beacon of the instrument landing system. It proposes a procedure for building an antenna array with two subarrays, one of which radiates a Carrier plus sideband signal (CSB) and the second one radiates a Suppressed carrier sideband only (SBO) signal. The authors find the conditions, under which the information parameter of the beacon (the Difference in the depth of modulation, DDM) in the area of the Glide path coverage does not depend on the height of the antenna array relative to the underlying surface. Measurements made by an aircraft laboratory confirmed the stability of the glide path position when changing the height of the snow cover to 110 cm using the proposed antenna array.

Poster_04.13 ***Introduction of Dynamic Virtual Force Vector in Particle Swarm Optimization for Automated Deployment of RFID Networks***

Antonis G Dimitriou and Stavroula Siachalou (Aristotle University of Thessaloniki, Greece); Aggelos Bletsas (Technical University of Crete, Greece); John Sahalos (Aristotle University of Thessaloniki, GR, Thessaloniki, Greece & University of Nicosia, CY, Nicosia, Cyprus)

A scheme for automated planning of passive RFID network is proposed. The scheme comprises two parts. The first part creates a fast site-specific probabilistic propagation model for successful identification from the reader of any possible tag antenna. The materials of surrounding walls as well the tag antenna's radiation pattern, the geometry and the polarization of both reader and tag are taken into account. In the second part, a hybrid form of particle swarm optimization (PSO) algorithm is applied. The proposed approach selects a subset of tag antenna configurations to be installed so that a given cost function is satisfied. By clustering problematic areas during each iteration and moving the swarms towards them, we imitate the acts of a human-planner. The combinatorial performance of all active readers is evaluated at each tag location; this reveals that good identification performance is recorded at overlapping regions, where no single reader- tag antenna operates adequately. The proposed clustering approach greatly improves the convergence-time of the standard PSO and greatly reduces equipment, cutting down the cost of the network accordingly. Comparison with standard PSO reveals that the overall equipment can be reduced by a factor of two, satisfying the same quality constraints.

Poster_04.14 ***Study of Double Ring Resonator Embroidered Wearable Antennas for Microwave Applications***

Bahareh Moradi, Marc Martinez and Raul Fernandez-Garcia (Universitat Politecnica de Catalunya, Spain); Ignacio Gil (Universitat Politècnica de Catalunya, Spain)

In this work, the design, implementation and test of double ring resonator (DRR) wearable antennas is carried out. Specifically, symmetrical and non-symmetrical DRRs are coupled to a transmission line by means embroidered metallic thread on a felt substrate. Both designs present good e-textile antenna parameters performance in terms of return loss, directivity, realized gain and efficiency. Moreover, the specific absorption rate (SAR) to preserve the human body safety from radiation has been analyzed by means of numerical simulations including a realistic human voxel model, according to the international regulation. Experimental results confirm that the embroidered DRR antennas present a useful technique to transmit/receive microwave signals on wearable applications.

Poster_04.15 ***Development of Design Rules for Chipless Radio-Frequency Identification with Enhanced Data Capacity***

Fei-Peng Lai, Tong-Yang Jiang and Yen-Sheng Chen (National Taipei University of Technology, Taiwan)

In this paper, the design guidelines for frequency-coded chipless radio-frequency identification (RFID) are proposed. We aim to clarify three issues in this application: the operating frequency band of a frequency-coded chipless RFID system having a data capacity of 21 bits, the design rules for the chipless tag, and the resonator configuration that leads to a narrow bandwidth. We evaluate 24 types of resonators, analyzing their characteristics of radar cross section (RCS) at different operating frequencies. The most crucial parameter that influences the RCS bandwidth is the width of the strip/slot of a resonator. Deriving from the parametric studies, we recommend that using 5 GHz as the upper limit of the operating frequency, despite the fact that an increasing amount of studies use ultra-wideband (UWB) to perform chipless RFID communications. Besides, we observe that a half-wave slot is particularly suitable to construct the chipless tag with high data capacity, as this configuration leads to a narrow bandwidth and good frequency scalability. The results provide design guidelines on the system parameters for the frequency-coded chipless RFID.

Poster_04.16 ***Impact of Heavy Rain on Signal Propagation in the UK and Mexican 4G and 5G Networks***

Yu Geng, Robert Michael Edwards, John Davis, Abdou Khouakhi, Ben Clark, Kyp Diamantides, Chen Dai and Michael Kaczmarczyk (Loughborough University, United Kingdom (Great Britain)); Victor Rangel (National University of Mexico, Mexico); Jesus Lopez and Oliver Cano (Colima University, Mexico); Raul Santos (University of Colima, Mexico); Paul Lepper and Ian Pattison (Loughborough University, United Kingdom (Great Britain))

Wireless sensor networks are a current area of interest for many researchers, however surprisingly few have actually been deployed. In this paper, we present preliminary results from a series of experiments designed to assess the viability of using existing mobile phone networks in developing countries to create flood warning systems. Creation of a flood warning network involves placing wirelessly connected nodes on all significant tributaries of a river system often over several hundreds of square kilometers. Rain is one of the principal causes of signal change in mobile networks. To assess the effect of the above on associated Internet of Things (IoT) flood alert systems, measurements were conducted in the UK and Mexico to determine the attenuation of a line of sight (LOS) and ground multipath propagation due to either rain or excess surface water. Both components are analyzed using ray tracing simulation software in addition to the real-time field measurements with the mobile handset 'app' G-NetTrack Pro. Measurement experience gleaned from the UK campaign has been used to formulate a more comprehensive handset based strategy in the Colima flood zone in Mexico, the results of which are also summarized in this paper. It is believed that both the above measurement and ray trace modeling exercises may be used to further optimize protocols required to address the propagation needs of future 4G/5G networks.

Poster_04.17 ***A Threshold Trade-Off Study for 3-Way Switch Diversity***

Jeff Frolik (University of Vermont, USA)

Selection diversity among multiple communication links is a well known approach to improve the over quality and reliability of wireless communications. However, to achieve in practice the theoretical performance gains requires real-time monitoring of each link. This is not tenable in practice for single- receiver hardware that is expected to be low in cost (e.g., for IoT deployments). A variation of selection diversity, known as switch diversity, can be implemented by a single receiver. In this work, we explore establishing thresholds to determine when to "switch away" from the presently used link and the resulting cost of doing so. In particular, we consider the case of having three independent Rayleigh fading paths and propose that establishing a threshold between -5 dB and -6 dB relative to the median received power provides a good trade-off between increasing diversity gain and reducing switching probability.

Poster_04.18 ***Bi-static delay-Doppler Emulation of Cooperative Passive vehicle-to-X Radar***

Andreas Schwind, Carsten Andrich, Philip Wendland and Michael Döbereiner (Technische Universität Ilmenau, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Guenter Schaefer (Technische Universitaet Ilmenau, Germany); Reiner S. Thomä and Matthias Hein (Ilmenau University of Technology, Germany)

Automotive radar systems are indispensable for advanced driver assistance systems. Beside existing monostatic radar techniques, bi-static radar sensing like passive coherent location offers additional options to improve the radar visibility of vulnerable road users. Regarding testing and evaluation of passive radar signal processing algorithms including parameter estimation, it is essential to provide electromagnetically shielded and reproducible measurement conditions, in addition to field tests in traffic scenarios. This paper describes the possibility to emulate relevant parameters for bi-static radar scenarios in the frequency range from 1 GHz to 6 GHz, like the bi-static angle between transmitter, target and receiver, and the resulting bistatic Doppler frequencies of a realistic vehicular traffic scenario, in a metal-shielded semi-anechoic chamber. According to the concept of cooperative passive coherent location, Doppler scattering measurements are presented with test setup and results, and compared with numerical simulations. We find reasonable agreement between measured and ground truth data in the delay- Doppler spectrum.

Poster_04.19 ***Spatial Consistency of Multipath Components in a Typical Urban Scenario***

Fjolla Ademaj and Stefan Schwarz (TU Wien, Austria)

Channel models should be accurate in reflecting a realistic behavior between transmitter and receiver. To be able to capture smooth variations of channels, i.e., when a user moves, or when multiple users are close to each other in a confined area, channels should include spatial correlation. There are various applications that make use of these smooth channel variations including beam tracking strategies and beam forming strategies based on angular information. In this paper we show a spatially consistent geometry-based channel model and compare it to a deterministic ray-tracing model. Characteristics of strongest multipath components in terms of delay and angles of arrival in azimuth and elevation over consecutive spatial locations in an urban environment, are evaluated. Our model for spatial consistency reveals a realistic behaviour and statistically is capable to mimic the appearance of new scatterers and disappearance of old ones, thus matching the outcome of ray-tracing modeling.

Poster_04.20 ***Influence of Reference Map Resolution on Indoor Terminal Positioning with the Use of RSSI Measurements and Particle Filter Algorithm***

Robert Kawecki, Piotr Korbel and Slawomir Hausman (Lodz University of Technology, Poland)

The article discusses the factors affecting the performance of indoor positioning system employing three main components: Bluetooth Low Energy (BLE) transmitters, received signal strength maps obtained by measurements, and a particle filter algorithm. The results of experimental analysis of the impact of the resolution of the received power distribution reference maps on the positioning accuracy has been shown. The relation between the resolution of the maps and processing speed and accuracy of the positioning algorithms has been presented, showing that careful selection of the map resolution can result in significant reduction of the computation time while maintaining the accuracy of the positioning system.

Poster_04.21 ***Statistical Analysis and Modeling of Vehicular Radar Cross Section***

Saw Myint (Technische Universität Ilmenau, Germany); Christian Schneider and Matthias Röding (Ilmenau University of Technology, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

The individual Radar Cross Section (RCS) of each vehicle is very important for detection, tracking, and classification in automotive radar applications. Apart from these typical radar applications, the bistatic RCS of vehicles can be applied as a scattering model within wireless propagation channel modeling for the evaluation of vehicular communication systems. Therefore, the bistatic RCS of typical vehicles is simulated by ANSYS-HFSS in the communication frequency band of 2.4 GHz. A parametric 3D model of a vehicle regarding its dimensions and shapes was investigated, it can vary from the small compact car to the high-end SUV, including various types of minivans and sedans. The simulated RCS data are analyzed to extract the statistical information. Based on these information, a statistical RCS model of three different vehicle sizes is derived.

Poster_04.22 ***Low Cost AoA Unit for IoT Applications***

Noori BniLam and Dennis Joosens (University of Antwerp - imec, IDLab Research Group, Belgium); Jan Steckel (University of Antwerp - Cosys-lab Research Group, Belgium); Maarten Weyn (University of Antwerp - imec, Belgium)

In this paper, we present a low cost Angle of Arrival (AoA) estimation unit that can be used as an Internet of Things (IoT) receiver and provides AoA estimations of the received signals. This AoA unit built based on adapting a single RF-channel Software Defined Radio (SDR) into a multiple RF-channels SDR. The proposed hardware has been tested in an anechoic chamber with an open source IoT standard. The experimental results show that the proposed AoA unit provides a very stable and accurate AoA estimations.

Poster_04.23 ***Space Time Channel Sounding Method Using SAR Approach***

Patrice Pajusco (TELECOM Bretagne, France); Emna Bel Kamel (IMT Atlantique, France); Nadine Malhouroux (Orange Labs); Rizwan Masood (Orange, France)

This paper explores the feasibility of direction of arrival (DoA) measurements with high angular resolution using a hybrid antenna array. The original concept is based on the design of a virtual planar antenna array synthesized by utilizing a real antenna array on the top of a moving vehicle. In order to validate this concept, a wideband channel sounder is developed using Software Defined Radio (SDR) module. The designed sounder is cost-effective, portable, compact and built with mainly off-the-shelf hardware. Preliminary measurements collected in suburban environments are used to validate the concept. Results demonstrate that the measured DoA's are coherent with the measurement configuration. This new approach makes it possible to carry out a large number of DoA measurements at the mobile in various environments.

Poster_04.24 ***Optimization of RFID-Based Tunnel Access Monitoring System Antenna Reading Areas***

Kai Kordelin (Faculty of Biomedical Sciences and Engineering, Tampere University of Technology, Finland); Johanna Virkki (Tampere University of Technology, Finland); Jaana Kordelin (Faculty of Biomedical Sciences and Engineering, Tampere University of Technology, Finland); Joel Kuusman (Cimcorp Oy, Finland); Jussi Mattila (Posiva Oy, Finland); Markku Johansson (Aitosolutions Oyj, Finland); Leena Ukkonen and Lauri Sydänheimo (Tampere University of Technology, Finland)

This work focuses on a nuclear waste storage facility's RFID (Radio Frequency Identification)-based access monitoring system and especially on antenna reading area mapping results. The objective of this research is to find out the effects of sprayed concrete bedrock caverns and height of reader antennas on RFID antenna reading areas. First, we will shortly introduce the access monitoring system, equipment, and program that have been developed for the tunnel system. Next, we describe the research area, the locations of the antennas, and the study protocol. Finally, we discuss the effects of sprayed concrete and antenna height on the antenna reading areas. Further, we introduce other noted factors that affect the reading area sizes, for example bedrock fractures and fillings. Based on the results, a sprayed concrete surface improves the reflectiveness of the radio signal and thus the reading capabilities of the ID (Identification)-cards. Another clear result was that the higher the antenna or ID-card was placed, the longer the MRRR (Maximum Reliable Read Range) range was.

Poster_04.25 ***A Wireless Power Charger System Using a 2-D Near-Field Array for Assisted Living Applications***

Qassim Abdullahi and Rahil Joshi (Heriot Watt University, United Kingdom (Great Britain)); Symon K. Podilchak and Apostolos Georgiadis (Heriot-Watt University, United Kingdom (Great Britain)); Dimitris E. Anagnostou (Heriot Watt University, United Kingdom (Great Britain)); Danmei Sun (Heriot Watt University, United Kingdom, United Kingdom (Great Britain)); Meixuan Chen (Heriot Watt University, United Kingdom (Great Britain)); Jean Rooney and John Rooney (Feel the Warmth, United Kingdom (Great Britain))

Wireless power transfer can enable connector-free systems that do not rely on more conventional wired connections. In this paper, a wireless battery charger for a wearable body heater, where the transmitting system is integrated into a chair, is reported for benefiting assisted living residences. This system incorporates the widely adopted Qi wireless charging standard that is accepted by industry. Alignment conditions between a 3×1 matrix array and a 3×3 coil matrix array are investigated in the form of voltage induced in the secondary coil. The results are useful in practical applications as they help define the seating areas for users to achieve the necessary wireless heating.

Poster_04.26 ***A MIMO-ready Hardware Platform for Digital Voice Communication at 2.45 GHz***

Jo Verhaevert, Patrick Van Torre, Michaël Braem and Hendrik Rogier (Ghent University, Belgium)

This paper documents the development of a hardware platform for digital voice communication in the 2.45 GHz band. The design is centered around an ADF7242 transceiver, applying IEEE802.15.4 modulation. Furthermore, the design works half-duplex and is capable to communicate alternating in both directions. On the transmit side, the sampled audio signal is processed by means of software written in C, running on the on-board microcontroller, which transmits the data to the transceiver over its SPI bus. On the receiving side, the opposite occurs. The received audio data goes to the DAC with a sample rate of 16 kHz, connected to an amplifier and speaker. Successful real-time digital voice transmissions were demonstrated with the prototype boards.

Poster_04.27 ***Transient Waves Along Electrical Transmission Lines. Waves in (1+1)-Spacetime***

Adrianus T De Hoop and Ioan E. Lager (Delft University of Technology, The Netherlands)

The properties of transient waves along electrical transmission lines are investigated. In particular, the excitation of the waves by impressed voltage and electric current sources is studied. Specific choices of this excitation are shown to lead to 'one-sided transmission' only. Furthermore, the reflection and transmission at a localized line fault/defect is studied. An illustrative time-domain reflectometry experiment is discussed.

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Chairs: Rafael F. S. Caldeirinha (Polytechnic Institute of Leiria & Instituto de Telecomunicações, Portugal), Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

Poster_07.1 ***Nanoscale Hyperbolic Metamaterial-based Glucose Sensor***

Muhammad Abuzar Baqir (Department of ELectrical and Computer Engineering, COMSATS University Islmabad, Sahiwal Campus, Pakistan)

The theme of the present communication is pivoted to the sensing features of biosensor made of hyperbolic metamaterial-(HMM). HMM-based sensor comprises three layers: bottom silicon (Si) substrate glass, over which HMM-layer has been fabricated, and the top layer is measurand (solution). HMM-layer has been designed by making subwavelength-sized periodic nanoholes in thin layer of gold (Au), and separation between adjacent nanoholes is of subwavelength-size. The effective dielectric constant of HMM-layer has been deduced by employing effective medium theory (EMT). The sensitivity has been determined in term of the shift in the reflection minima of light corresponding a change in the concentration of the measurand (an aqueous solution of glucose). As such, sensitivity of the proposed sensor has been analyzed in near-infrared regime of light. The observations reveal that sensitivity depends on thickness of the HMM- layer. Such a sensor would be useful for the sensing applications in integrated optics.

Poster_07.2 ***Quick-Decision Method to Improve the Electromagnetic Compatibility Performance of Multi-Antenna System***

Xie Ma and Dongyuan Shen (China Electronics Technology Cyber Security Co., Ltd., P.R. China); Eugene Sinkevich and Mordachev Vladimir (Belarusian State University of Informatics and Radioelectronics, Belarus)

This paper presents a method to evaluate estimated coupling degree value of all available antenna layout schemes for vehicular system. In the proposed method, all possible antenna layout schemes located on installable positions of platform for antennas are required to analyze, and every antenna is supposed to be paired with rest ones in each scheme. According to the performance analysis and spectrum analysis of the system, each pair of antennas is weighted by the effects of the interference between them to the system. With commercial electromagnetic simulation software and numeric post-process, it is possible to determine the lowest interference coupling antenna layout scheme for the vehicular system based on the weight factors. For validating the feasibility of this method, an example application is demonstrated by using actual field test data.

Poster_07.3 ***Simple Calculation Method for Conformal Beam-Scanning Array Pattern***

Hirokazu Kobayashi (Osaka Institute of Technology, Japan)

In this paper, we discuss a simple beam-scanning calculation method for conformal array with arbitrary shaped surface. In order to scan a beam of array antenna with the curved surface, it is necessary to calculate optical path-length from each antenna element to an aperture plane, so called "equi-phase front", which is perpendicular to scanning beam direction. Furthermore, normal vectors and polarized direction of each element are needed. For these calculation, we propose a new algorithm which can calculate the path-length (driving phase input to each element) by employing the direction-cosine relation between the beam direction and each element. Using this direction-cosine, the path-length can be easily and generally obtained for arbitrary shaped conformal array. Furthermore, if the shape of array surface is expressed by polynomial equation, normal vector and polarized direction of element antenna can be analytically determined. Polarization loss of the element and shadowing procedure, which depend on beam direction, can also be calculated. Taking these relations into consideration, we show radiation patterns for polynomial curved surface array with curved rectangular patch element by using array-factor.

Poster_07.4 ***Leaky Lens Photo-Conductive Pulsed THz Emitters***

Paolo Sberna (Delft University of Technology, The Netherlands); Alessandro Garufo (TNO & Delft University of Technology, The Netherlands); Giorgio Carluccio (Delft University of Technology, The Netherlands); Juan Bueno (SRON Netherlands Institute for Space Research, The Netherlands); Joshua R Freeman (University of Leeds, United Kingdom (Great Britain)); Dave Bacon (University of Leeds, The Netherlands); Jochem Baselmans (SRON, The Netherlands); E. Linfield (School of Electronic and Electrical Engineering, University of Leeds, United Kingdom (Great Britain)); Alexander Davies (University of Leeds, United Kingdom (Great Britain)); Nuria LLombart and Andrea Neto (Delft University of Technology, The Netherlands)

Laser pumped photo-conductive lens antennas (PCAs) exploit the ultra-short photoconductivity phenomenon of specific semiconductors in order to generate pulsed radiation in the THz regime. State of the art PCAs suffer from high dispersion and low radiation efficiency over the large generated bandwidth due to the poor coupling between the antenna and the dielectric lens. In this work a leaky lens PCA is designed and proposed in order to overcome these issues. The presented structure, indeed, aims at a 1:15 bandwidth (0.1 THz - 1.5 THz). The electromagnetic analysis and the power budget of the leaky lens PCA are shown and compared to a standard PCA, with the same antenna geometry, demonstrating the much higher non-dispersive radiation efficiency of the former device, under the same optical excitation. The manufacturing process for realizing the device is also discussed.

Poster_07.5 ***Miniaturization, Selectivity and Rejection Bandwidth Improvements of a Multi-Band Stopband Filter Based on Circular Split Ring Resonator***

Badiaa Ait Ahmed (ENSA, LaSIT- FS- UAE University, Tetuan, Morocco); Hicham Klaina (University of Vigo, Spain); Otman Aghzout (ENSA Tetouan - UAE, Morocco); Ana Alejos (Universidade de Vigo, Spain); Azzeddin Naghar (BSA-Innovation LAB Radio Frequency Systems RFS, Lannion, France); Francisco Falcone (Universidad Publica de Navarra, Spain)

This paper presents a stopband filter design with null gapping between coupled microstrip lines embedded by short-circuited ring resonators. The open and split ring resonators are integrated along the 50-Ω transmission line. Important achievements in size and creation of multiple resonances covering S-band, C-band, X-band, and Ku-band are obtained. Firstly, we load the filter by symmetrical single open ring resonators; this design allows important shifting to lower frequencies accompanied with the appearance of dual band and wide rejection bandwidth of approximately 57.34%. It's noticed that, the proposed filter presents many advantages in comparison with a similar one loaded by stubs. Secondly the filter is loaded by two symmetrical coupled SRR resonators. It is demonstrated that more shifting toward low frequencies and multi-band stopbands are obtained with improvements in selectivity and rejection bandwidth. L-C equivalent circuit models and current distribution for each case were presented and investigated.

Poster_07.6 ***A Planar SIW Cavity-backed Tilted-Slots Antenna for WBAN Application***

Divya Chaturvedi (NIT Trichy, India); Arvind Kumar (National Institute of Technology, Trichy India & National Institute of Technology, Trichy India, India)

This paper presents a compact and planar cavity-backed antenna for wireless body area network (WBAN) application at 5.8 GHz. The planar cavity is realized using Substrate Integrated Waveguide (SIW) technology. The SIW cavity consists of two rectangular-tilted slots and two metalized via holes. The slots are introduced on the top plane for radiation while metalized vias are introduced in proximity of the slots to enlarge the impedance bandwidth. To evaluate the on-body performance, a pork muscle equivalent phantom is used in simulation studies. The simulated -10 dB impedance bandwidth is 270 MHz (5.63-5.89 GHz) which fully covers the Industrial, Scientific and medical (ISM) band. The SAR Value per 10 g mass of tissue is 1.45 mW/g with input power of 100mW which is satisfactorily below than specified FCC limits.

Poster_07.7 ***Pattern Reconfigurable Resonance Based Reflector Antenna for Thorax Imaging***

Sasan Ahdi Rezaeieh and Amin Abbosh (The University of Queensland, Australia)

The design and analysis of a pattern reconfigurable resonance based reflector antenna is presented. The antenna is designed to meet the light weight, compact size, wide bandwidth and unidirectional radiation requirements of thorax imaging systems. It is comprised of a dipole antenna that is vertically positioned on top of a loop structure. The loop antenna operates both as a resonator and a reflector at the same time, thus creating a wide operating bandwidth and a unidirectional radiation. To reduce the lateral size of the antenna, a C-shaped structure is utilized to increase the electrical length of the dipole-antenna without physically altering its dimensions. To switch the radiation beam of the antenna at different directions without using mechanical rotation, the position of the dipole's arms are electronically altered. Consequently, this creates three virtual dipoles, which enable switching the radiation pattern at the direction of the active one. The proposed antenna achieves a compact size of 0.32λ× 0.32λ with respect to the wavelength at the lowest operating frequency of the antenna. It achieves a maximum fractional bandwidth of 41% at 0.8-1.21 GHz with a peak gain and front-to-back-ratio (FBR) values of 5.9 dBi and 15 dB, respectively, with a scanning range of ±27 degrees at the elevation plane.

Poster_07.8 ***Effect of Textile Properties on a Low-Profile Wearable Loop Antenna for Healthcare Applications***

Mohammed Bait-Suwailam (Sultan Qaboos University, Oman); Isidoro Labiano and Akram Alomainy (Queen Mary University of London, United Kingdom (Great Britain))

In this paper, numerical and experimental studies on performance evaluation of low-profile wearable loop antenna for healthcare monitoring applications are conducted.Parametric studies on the effect of textile cotton fabric properties, considering the electrical permittivity and substrate thickness, are investigated in order to evaluate the trend on loop antenna's resonance behavior. Experimental validation is also carried out and comparison is made. Good agreement between modeled wearable loop antenna and the fabricated one was obtained, with almost 3% shift in resonance frequency, due to the estimated textile properties within the simulation model. The effect of implanting the wearable antenna on close-proximity to a modeled arm phantom is also numerically studied and assessed.

Poster_07.9 ***Evaluation of the Influence of Frequency on Effectiveness of Microstrip Device Miniaturization by Means of Artificial Transmission Lines***

Denis Letavin and Sergey Shabunin (Ural Federal University, Russia)

The influence of central frequency on effectiveness of branch-line coupler miniaturization was investigated. Miniaturization consists in substituting the microstrip transmission line with an equivalent artificial transmission line. Several couplers with different central frequency were designed, modeled and manufactured. The frequency characteristics of the designed devices and couplers with traditional topology were measured and analyzed. The comparison of the area occupied by the directional coupler with the traditional topology and compact one with artificial lines is carried out as well. It is shown that the benefit in reducing the coupler size is much greater than the loss caused by the reduction the operating frequency band if the same substrate is used.

Poster_07.10 ***Algorithmic Implementation of a Hybrid 2D Finite Element - Mode Matching Method Based on Nested Function Spaces***

Juan Córcoles (Universidad Autónoma de Madrid, Spain); Jorge A Ruiz-Cruz (Universidad Autonoma de Madrid & Escuela Politecnica Superior, Spain); Raúl Haro-Báez (Universidad Autónoma de Madrid, Spain)

This work reports an algorithmic implementation of a hybrid finite element (FE) - mode matching technique based on the concept of nested 2D FE function spaces, suited to analyze waveguide components with diverse geometries as for instance transformers or polarizers for antenna feeds. Thanks to this technique, the inner cross product matrix in the mode matching method is readily built from precomputed FE matrices, which are already available from the mode computation in irregularly shaped cross-sections. Thus, this work focuses on the implementation of this technique such that critical steps are carried out in an efficient way (i.e. sparse matrix-vector products, vector-vector dot products, etc.). To that effect, a very powerful and flexible FE open source computing platform, namely FEniCS, along with its high-level Python interface, has been used.

Poster_07.11 ***A Compact Wideband ACS-fed Monopole Antenna for Wireless Applications Around 2.45 GHz***

Mohsen Koohestani (ESEO-IETR, France); Jerome Tissier (ESEO & IETR, University of Rennes 1, France); Mohamed Latrach (Radio-Frequency and Microwave Research Group, IETR-ESEO, Angers & ESEO, Graduate School of Engineering, France)

A compact wideband printed monopole antenna is proposed for wireless applications around 2.45 GHz. The antenna structure comprises a quarter circle united with a rectangular section and a flipped ground plane of similar geometry as the patch. It is fed through an asymmetric coplanar strip (ACS) by a SMA connector at an optimized location. The overall size of the antenna is only 38 x 10.8 x 0.8 mm3. Simulation and experiment are performed to validate the design. Results show that the antenna operates in the frequency range from 2.35 to 2.64 GHz (11.5%) based on |S11|<-10 dB, and radiates nearly omni-directionally over the frequency bandwidth. The simple structure, compact size, and wideband characteristics make the proposed antenna a suitable candidate for broad range of applications in the available wireless communication standards.

Poster_07.12 ***Compact Textile Wideband Antenna for Wearable Microwave Stroke Imaging***

Xiaoyou Lin (University of Waikato, New Zealand); Yifan Chen (The University of Waikato, New Zealand); Boon-Chong Seet (Auckland University of Technology, New Zealand); Fen Xia (Southern University of Science and Technology, P.R. China); Qingfeng Zhang (South University of Science and Technology of China, P.R. China); Jun Hu (University of Electronic Science and Technology of China, P.R. China)

This paper proposes the design of a low-profile compact textile antenna for wearable microwave stroke imaging systems. The antenna is designed on flexible polyester fabrics and can be printed with silver conductive inks. Because the operating bandwidth of conventional monopole antennas can hardly meet the requirements for the microwave stroke imaging applications, two triangles and a few parallel slots are cut at the bottom corners and the top edge of the antenna's radiation patch, respectively, to increase the current path of the proposed antenna. The simulation shows that the proposed antenna has an ultra-wide -10-dB operating bandwidth of 125% from 1.13-4.88 GHz, a reasonably high radiation gain and dipole-like radiation patterns. The simulation further proves that the antenna can maintain a wide bandwidth and promising gain when it is working in the proximity of human bodies.

Poster_07.13 ***Influence of Air-gaps Between Antennas and Breast on Impulse-Radar-Based Breast Cancer Detection***

Takamaro Kikkawa and Hiromasa Watanabe (Hiroshima University, Japan); Xia Xiao (Tianjin University, P.R. China); Hang Song (Hiroshima University, Japan)

The objective of this study is to investigate experimentally the influence of air-gaps between a breast skin surface and antennas of impulse-radar-based breast cancer detector on confocal imaging. The detector employs 16 rotating antennas covered with a radome contacting the surface of the breast phantom without a coupling medium. The detector can detect a breast cancer phantom target even under the imperfect contact condition between the breast skin surface and the antennas.

Poster_07.14 ***An Efficient Approach for Electromagnetic Analysis of Radomes Antennas Using Characteristic Basis Function Method***

Eliseo García and Carlos Delgado (Alcala University, Spain); Lorena Lozano (University of Alcala, Spain); Ivan Gonzalez (Universidad de Alcala, Spain); Felipe Cátedra (University of Alcala, Spain)

A novel approach for the analysis and design of radomes is presented. It uses full domain macro-basis functions obtained from the Characteristic Basis Function Method (CBFM), for modeling the radome structure. The presented approach can be used to analyze arbitrary-shaped radome antennas with several material layers composed by different thickness and different dielectrics. Some cases of study are presented in order to validate the new method.

Poster_07.15 ***Reducing Elements in Linear Antenna Array Using Levenberg-Marquardt Algorithm***

Ariel Waremstein and Nezah Balal (Ariel University, Ariel, Israel); Yosif Pinhasi (Ariel Universoty Center of Samari, Israel)

Design of a non-uniform antenna array with reduced number of elements may be required for some applications. This paper introduces an iterative procedure, which is based on the Levenberg-Marquardt Algorithm (LMA), for reducing the number of elements in a linear array. By applying small perturbations on a given configuration, the algorithm finds the gradient that makes the total square error to be minimal, and then tests the new point in this direction until it converges to an optimal positions, amplitudes and phase, of array elements, regarding array factor requirements. Sensitivity of the resulted design to amplitude and frequency errors is examined. Simulation CST results of the theatrical design is also carried out, demonstrating the accuracy of the algorithm.

Poster_07.16 ***Efficient Implementation of BOR FDTD Algorithms in the Engineering Design of Reflector Antennas***

Marzena Olszewska-Placha (QWED Sp. z o. o., Poland); Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); Malgorzata Celuch (QWED, Poland); Maciej Sypniewski (Warsaw University of Technology, Poland)

This work presents a modelling-based methodology for the design and evaluation of axi symmetrical antennas, including horns, compact and large dual reflector antenna systems. The starting concept of the antenna is an educated guess stemming from the engineer's experience; however, further evaluation and optimization of that concept continue in a computational loop that involves a conformal FDTD algorithm in a BOR formulation. Our BOR FDTD retains the advantages of general-purpose 3D FDTD software, providing full-wave solutions and delivering key engineering parameters of antenna systems together with an insight into the distribution of the electromagnetic near-field, a useful feature to assess the mismatch of the horn due to the subreflector interaction. At the same time, the unique BOR formulation accelerates the analysis by orders in magnitude, making it practical to evaluate many designs within a manual or automatic optimization loop. We also show that BOR FDTD compares favourably with the Mode Matching Technique, being computationally fast while obviating the MMT inherent structural assumptions.

Poster_07.17 ***2-D Inhomogeneous Frequency Dependent Metasurface-Cylinder Based Absorbing Boundary Conditions***

Shraman Gupta, Dhruva Kumar Chandrappa and Abdel R. Sebak (Concordia University, Canada)

The combination of metasurface and metal cylinders using inhomogeneous frequency dependent medium properties is presented in this paper. The idea of Metasurface Absorbing Conditions (MS-ABC) using surface current approach is used to define the boundary conditions to have richer absorption avoiding the physical placement of metasurface via its virtual network. The surface currents include both electric and magnetic polarization currents. The exact modeling of the metasurface surface currents is done using Generalized Sheet Transition Conditions (GSTC) synthesis. The material properties are inhomogeneous, where the permittivity inside the computational domain depends upon the frequency. Therefore, the analysis of slow and fast propagating waves are analyzed using two dimensional (2D) Finite Difference Time Domain (FDTD) scheme. In addition, the metal cylinders are placed at the metasurface boundaries illustrating the behavior of reflected waves in the total field region.

Poster_07.18 ***Numerical Comparison of Magnetic Biomaterials for Hyperthermia Applications: The Osteosarcoma Case***

Matteo Lodi (University of Cagliari, Italy); Giuliano Vacca (University of Genova, Italy); Alessandro Fanti (University of Cagliari, Italy); Lorenzo Luini (Politecnico di Milano, Italy); Giuseppe Vecchi (Politecnico di Torino, Italy); Giuseppe Mazzarella (University of Cagliari, Italy)

The aim of this work is to evaluate the therapeutic performances of novel magnetic biomaterials developed for hyperthermia treatment of bone tumors in a numerical multiphysics scenario. A brief report of the state of the art of innovative and functional magnetic implants is provided. Then, the non-linear model for the heat dissipation during the hyperthermia treatment is explained and discussed. Finally, the performances of different magnetic biomaterials in treating Osteosarcoma tumor are presented and critically compared.

Poster_07.19 ***Low-Power Communication for an Implanted Intracortical Visual Prosthesis***

Adedayo Omisakin and Rob Mestrom (Eindhoven University of Technology, The Netherlands); Mark Bentum (Eindhoven University of Technology & ASTRON, The Netherlands)

Assisting visually impaired people to see again using technology is challenging, especially for cases where most of the visual pathway is damaged. Sending the stimulation data to electrodes on the visual cortex is preferably done wirelessly to avoid infections and to ease mobility. The receiver on the implant poses a challenge in design, as the power supply is limited. In this paper, vital system requirements for this communication link are discussed. A low power system-level approach is presented which seeks to avoid power hungry components. This leads to the consideration of a bandpass sampled phase keying scheme via an inductive link. We propose a non-coherent digital demodulator, which relaxes the need for low phase noise oscillators which consume more power. The overall communication system has a potential to deliver stimulation data to the implant side in the presence of simultaneous power transfer and reception of recorded data from the brain.

Poster_07.20 ***Plane Wave Diffraction by a Non-Planar DPS-DNG Junction in the Case of Normal Incidence***

Gianluca Gennarelli (IREA-CNR, Italy); Giovanni Riccio (University of Salerno, Italy)

This paper solves the diffraction problem associated to a plane wave impacting a non-planar junction of two lossy planar slabs with different electric and magnetic characteristics. One slab consists of a standard double positive material whereas an unusual double negative metamaterial is used for the other slab. A uniform asymptotic solution is proposed in the framework of the uniform theory of diffraction when the incidence direction is orthogonal to the edge of the junction. Such a solution is based on the physical optics approximation of the electric and magnetic equivalent surface currents assumed as radiating sources in the surrounding space and used in the far-field radiation integral. This last denotes the starting point of an analytical procedure that provides closed form expressions containing the transition function of the uniform theory of diffraction and the geometrical optics contribution of the junction. The resulting diffracted field is able to compensate the jumps of the geometrical optics field at the shadow boundaries.

Poster_07.21 ***Analysis Technique for Radiation Problems with Multiple Sources Combining Ray-Tracing and Macro-Basis Functions***

Carlos Delgado and Eliseo García (Alcala University, Spain); Lorena Lozano, Felipe Cátedra and Alvaro Somolinos (University of Alcala, Spain)

This document presents a numerical approach for the solution of large electromagnetic problems using a preliminary ray-tracing analysis in order to determine the number of high-level macro-basis functions to be assigned to each block. It is especially tailored to problems with multiple sources or excitations. We provide expressions to update the threshold levels for the truncation of the number of Macro Basis Functions based exclusively on the position of the sources or including their radiation pattern.

Poster_07.22 ***Monitoring of Electromagnetic Energy Flow in a Confined Region of Evanescent Waves by an Alternative Expression for the Poynting Vector***

Hovik Baghdasaryan, Tamara M. Knyazyan and Tamara Hovhannisyan (National Polytechnic University of Armenia, Armenia); Ara Daryan (A. Alikhanyan National Laboratory, Armenia); Marian Marciniak (National Institute of Telecommunications, Poland)

For monitoring of energy flow an alternative expression for the Poynting vector is presented. This expression is an intrinsic integrable function at the boundary problem solution by the method of single expression (MSE). The MSE does not exploit the superposition principle, i.e. does not represent solutions of Helmholtz equation as the sum of counter - propagating waves. This permits to have an alternative expression for the Poynting vector applicable both in media of a positive product of permittivity and permeability and of a negative product that relevant to the region of evanescent waves as well. At the boundary problem solution by the MSE (that is carried out numerically) it is possible to observe spatial distributions in confined media not only for electric and magnetic field amplitudes, but also the Poynting vector.

Poster_07.23 ***Acceleration of the Discrete Green's Function Formulation of the FDTD Method Based on Recurrence Schemes***

Jacek Gulgowski (University of Gdansk, Poland); Tomasz P Stefanski (Gdansk University of Technology, Poland)

In this paper, we investigate an acceleration of the discrete Green's function (DGF) formulation of the FDTD method (DGF-FDTD) with the use of recurrence schemes. The DGF-FDTD method allows one to compute FDTD solutions as a convolution of the excitation with the DGF kernel. Hence, it does not require to execute a leapfrog time-stepping scheme in a whole computational domain for this purpose. Until recently, the DGF generation has been the limiting step of DGF-FDTD due to large computational resources, in terms of processor time and memory, required for these computations. Hence, we have derived the no-neighbours recurrence scheme for one-dimensional FDTD-compatible DGF using solely properties of the Gauss hypergeometric function. Using known properties of GHF, the recurrence scheme is obtained for arbitrary stable time-step size. In this paper, we show that using the recurrence scheme, computations of 1-D FDTD solutions with the use of the DGF-FDTD method can be around an order of magnitude faster than those based on the direct FDTD method. Although 2- and 3-D recurrence schemes for DGF (valid not only for the magic time-step size) still need to be derived, the 1-D case remains the starting point for any research in this area.

Poster_07.24 ***Quasi-analytical Near-to-Far Field Transformation Based on Field Matching Method for Scattering Problems***

Malgorzata Warecka, Piotr Kowalczyk and Rafal Lech (Gdansk University of Technology, Poland)

A new quasi-analytical near-to-far field transformation based on field matching method (field expansion in a base of Hankel functions) is presented. This approach uses finite element method to obtain near field, then the field is expressed in a base of Hankel functions. The evaluated coefficients allow to calculate the field outside the numerical domain, also in a far distance. The main advantage of the proposed technique is avoiding of the Green's function integration. The method can be applied for obstacles of an arbitrary cross section and homogeneous in one direction. In order to confirm the validity of the presented technique three different structures were analyzed and the results were verified with the other methods.

Poster_07.25 ***Scattering and Propagation Analysis for the Multilayered Structures Based on Field Matching Technique***

Malgorzata Warecka, Rafal Lech and Piotr Kowalczyk (Gdansk University of Technology, Poland)

A semi-analytical method is employed to the analysis of scattering and guiding problems in multilayer dielectric structures. The approach allows to investigate objects with arbitrary convex cross section and is based on the direct field matching technique involving the usage of the field projection at the boundary on a fixed set of orthogonal basis functions. For the scattering problems the scattered field in the far zone is calculated and for the guiding problems a complex root finding algorithm is utilized to determine the propagation coefficients. The results are compared with the alternative solutions in order to verify the validity of the proposed method.

Poster_07.26 ***Atmospheric Integrated Water Vapor Estimation Through Microwave Propagation Measurements Along Ground-To-Air Radio Links***

Alberto Toccafondi, Federico Puggelli and Matteo Albani (University of Siena, Italy); Luca Facheris (University of Florence, Italy); Fabrizio Cuccoli (RaSS CNIT & Dep. of Electronic and Telecommunications, Univ of Firenze, Italy); Giovanni Macelloni (IFAC-CNR Firenze, Italy); Francesco Montomoli (IFAC-CNR, Italy); Alessio Cucini and Francesco Mariottini (Wavecomm S. r. L., Italy); Luigi Volpi (PMS, Italy); Devis Dei (Florence Engineering, Italy); Marco Gai (Laboratori Vittoria, Italy)

The estimation of water vapor (WV) content in the lowest part of the troposphere is a critical issue which, up to now, cannot be obtained from space measurements with sufficient accuracy. A new technique, which is based on Ku-K band microwave measurements of the differential attenuation of two signals transmitted at closely spaced frequencies, has been recently proposed. In order to prove the effectiveness of this technique a low-cost microwave instrumentation was designed and the first measurements were performed by means of a ground-to-ground link. Instrument design and characteristics, as well the results of the first measurement campaign are presented here.

Poster_07.27 ***Propagation and UWB Channel Characteristics on the Human Abdomen Area***

Mariella Särestöniemi (Erkki Koiso-Kanttilan katu 1 & Center for Wireless Communication, University of Oulu, Finland); Chaïmaâ Kissi (Ibn Tofail University & National School of Applied Sciences (ENSA), Morocco); Carlos Pomalaza Raez (Purdue University, USA); Marko Sonkki, Matti Hämäläinen and Jari Iinatti (University of Oulu, Finland)

In this paper, channel characteristics and propagation on the human abdomen area, in particular small intestine part, are evaluated with a recently published low ultrawideband cavity-backed antenna designed for intra-body communication. The study is carried out with finite integration technique based electromagnetic propagation simulations. The main target of this study is to evaluate different antenna locations and antenna distances for the context of the wireless capsule endoscopy localization. The study is carried out by evaluating frequency and time domain responses, as well as studying the strength of the E-fields and power inside the small intestine by introducing monitor points with different antenna location options. Furthermore, 3D power flow figures are used as novel way to gain insight to the power flow and to the propagation in general within the tissues. It is shown that channel characteristics and power flow vary significantly with frequency as well as with different antenna locations.

Poster_07.28 ***EMF Exposure Analysis of Combining Specific Absorption Rate and Incident Power Density Using Canonical Dipoles***

Wang He (Zhejiang University, P.R. China); Zhinong Ying (SONY Mobile Communications AB, Sweden); Sailing He (Zhejiang University, P.R. China)

The millimeter-wave (mmWave) band has been allocated to the next generation (5G) mobile communication. For 5G devices, the dosimetric quantity of the electromagnetic field (EMF) exposure is the incident power density (IPD) above 6 GHz in lieu of the specific absorption rate (SAR) below 6 GHz. When exposed to sub-6-GHz antennas and above-6-GHz antennas simultaneously, total exposure ratio (TER) could be applied to evaluate EMF exposure. However, TER is not easy to measure because of the alignment difficulty between the SAR and IPD measurement set-ups. To avoid the alignment problem, based on the Gaussian distribution approximation of the SAR or IPD on the skin surface from canonical dipoles, an approximate expression of TER is given in this work. Because of the transition from SAR to IPD, the TER expression lacks a good linear correlation with temperature increase in human tissue. In this paper, we propose the temperature-based TER (TBTER) expression to represent the EMF exposure to human tissue to protect from excessive heating.

Poster_07.29 ***Analytical Method, Based on Slater Perturbation Theorem, to Control Frequency Error When Representing Cylindrical Structures in 3D Simulators***

Giorgio Sebastiano Mauro (INFN-LNS, Italy); Antonio Palmieri and Francesco Grespan (INFN-LNL, Italy); Giuseppe Torrisi, Ornella Leonardi and Luigi Celona (INFN-LNS, Italy); Gino Sorbello (University of Catania, Italy); Andrea Pisent (INFN-LNL, Italy)

When simulating electrically large complex structures such as Drift Tube Linac (DTL) cavities in 3D simulators, it is important to choose a model representation that is a compromise between accuracy and time/resource cost. This paper presents an analytical method, based on Slater perturbation theorem, to control frequency error and obtain a fairly accurate 3D mesh to represent cylindrical structures.

Poster_07.30 ***Fast Analysis of Arrays of Antennas Fed by Substrate Integrated Waveguides***

Jesús Rubio (University of Extremadura, Spain); Alfonso García (Universidad de Extremadura, Spain); Rafael Gómez Alcalá (University of Extremadura, Spain); Jesus Garcia (Universidad Politecnica de Madrid, Spain); Yolanda Campos-Roca (University of Extremadura, Spain); José Gil (Universidad Politécnica de Madrid, Spain); Miguel A. González de Aza (Universidad Politecnica de Madrid, Spain)

This communication introduces a fast methodology for the analysis of arrays of antennas placed on a ground plane that are fed by means of Substrate Integrated Waveguides (SIW). The methodology is based on the use of a numerical method to analyze each element, and the simultaneous use of cylindrical modes and spherical modes to connect the elements in the SIW layer and in the radiation region, respectively.

Poster_07.31 ***A Hybrid Approach for the Optimal Synthesis of Shaped-Beams Through Generic Arrays***

Giada Battaglia (Università Mediterranea di Reggio Calabria, Italy); Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Andrea Francesco Morabito (University Mediterranea of Reggio Calabria, Italy); Gino Sorbello (University of Catania, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

In this communication, we propose an innovative approach to the mask-constrained power synthesis of shaped beams through fixed-geometry array antennas having whatever kind of structure/layout and being composed by whatever radiating elements. The approach takes advantage from the convexity of the problem with respect to excitations and exploits a global optimization procedure on the field phase shifts over (a very reduced number) of control points.

Poster_05: Poster_05

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Space / Poster Session / Antennas

Room: Poster Sessions: P3 - Warta

Chairs: Max James Ammann (Dublin Institute of Technology, Ireland), Alberto Reyna (Autonomous University of Tamaulipas, Mexico)

Poster_05.1 ***Beamforming Techniques for a Quad-Mode Antenna Array***

Geomarr Van Tonder and Petrie Meyer (Stellenbosch University, South Africa)

Various excitation strategies are investigated for an 2x2 array of quad-mode antennas (QMA's), with the aim of achieving maximum gain over a full hempishere. The first determines a fixed excitation for the four ports of one QMA, achieving a gain pattern with a gain variation of only 1.7 dB across a full hemisphere. Four of these antennas are then beamformed. This is compared to a system in which all sixteen ports of a 2x2 QMA array are used for beamforming. It is shown that the first case results in a reduction of 5dB with respect to the second, but using only four beamforming channels instead of sixteen.

Poster_05.2 ***Fly's Eye Lens Phased Array for Submillimeter Wavelengths***

Sjoerd Bosma (Delft University of Technology, The Netherlands); Maria Alonso-delPino (Jet Propulsion Laboratory, USA); Darwin Blanco and Nuria LLombart (Delft University of Technology, The Netherlands)

In this contribution, we propose a hybrid electro-mechanical scanning antenna array architecture suitable for highly directive phased arrays at submillimeter wavelengths with field-of-views (FoV) of +/-30 degrees. The concept relies on combining electrical phase shifting of a sparse array with a mechanical translation of a fly's eye array of lenses (quasi-optical true time delay phase shifters). The use of a sparse phased array significantly simplifies the RF front-end (number of active components, routing, thermal problems), while the translation of a fly's eye lens array steers the element patterns to angles off-broadside, reducing the impact of grating lobes over a wide FoV. The mechanical translation required for the array of lenses is also significantly reduced compared to a single large lens, leading to faster mechanical implementation. In order to achieve wide bandwidth and steering angles, a novel leaky wave feed concept is also introduced. A 540 GHz prototype is currently under fabrication.

Poster_05.3 ***Flashover Analysis of Near-Space Antenna Mounting Insulators***

Tomasz Aleksander Miś (Warsaw University of Technology & Institute of Radioelectronics and Multimedia Technology, Poland)

This paper discusses the problem of the flashovers of the insulators supporting long antennas in balloon flight applications. The antennas are to be operated in the stratosphere, where the low air pressure increases the risk of flashover. To analyze the problem, the Paschen's law was applied to three thermodynamic data sets. To estimate the influence of the humidity present in the cloud layers, a humid flashover case, previously investigated by the RCA on ground, was re-calculated for stratospheric environment. The analyses show that the flashover voltage decreases rapidly with pressure-determined altitude and is higher for colder months of the year, which makes the system safer. Higher humidity reduces significantly the maximum flashover voltage, even the air gap remained three times larger than for the dry flashovers. Basic design requirements were formed for the stratospheric antenna mounting insulator in order to maintain the flight safety during high voltage operations.

Poster_05.4 ***V/W-Band Antenna Feed for Feeder Uplink of High Throughput Satellite***

Romain Contreres, Baptiste Palacin, Gwenn Le Fur, Maxime Romier and Vincent Laquerbe (CNES, France)

The paper presents the design of a dual polarized and dual band feed for V/W-band for Feeder Uplink of High Throughput Satellite. The simulated performances are discussed. The feed manufacturing is in process and the measurement will follow.

Poster_05.5 ***Triple-Bands Ka-Band Frequency Selective Surface Filter with Different Polarized Transmitting Performance in Each Band***

Masoud S. M. Mollaei (Aalto University, Finland); Reza Heydarian (Guilan University, Iran); Esmaeel Zanganeh and Seyyed Hassan Sedighy (IUST, Iran)

A triple-bands frequency selective surface (FSS) filter composed of combined enhanced Jerusalem and Gangbuster unit cells over square substrate integrated waveguide (SIW) cavities is presented. The enhanced Jerusalem cells produce two pass-bands with rotated polarization outputs while the enhanced Gangbuster one produces one pass-band with same polarized outputs in comparison with the input wave polarization. The pass-bands of the proposed FSS are at 33.5 GHz, 35.1GHz and 36.8 GHz. The simulation results verify the proposed idea ability and capability.

Poster_05.6 ***Design of Dual-Reflector Offset Antennas and Beam-Waveguides with a Pattern Symmetry and Zero Cross-polarization***

Igor Belkovich, Boris Kogan and Vasily Seleznyov (National Research University Moscow Power Engineering Institute, Russia)

Quasi-optical transmission lines - beam-waveguides (BWG) consisting of several offset reflectors are often used in feed systems of large reflector antennas. The main requirement to the beam-waveguides is minimizing losses and distortions of the initial field distribution, that is, maintenance the input pattern symmetry and zero cross-polarization. Traditionally, Mizusawa's criteria are used for the beam-waveguide design in order to meet these requirements. The fulfillment of these criteria results in the equality of the input and output beamwidths, which imposes restrictions on the feed system configuration. In this paper, the general criteria for the beam-waveguide design are presented. The beam-waveguide designed according to the general criteria maintains the pattern symmetry and zero cross-polarization in the propagating wave, while also allowing to transform the beamwidth. The criteria are developed within the geometrical optics approximation. Theoretical foundations of the developed approach are given and a method of BWG synthesis with a given beamwidth transformation coefficient is presented in the paper. A dual-reflector beam-waveguide is designed and simulated in order to demonstrate the method and verify the results. The developed criteria are also applicable to offset antennas.

Poster_05.7 ***Compact K/Ka Dual-Band Antenna on Gap Waveguide Technology***

Miguel Ferrando-Rocher (Universitat Politècnica de València, Spain); José Ignacio Herranz-Herruzo and Alejandro Valero-Nogueira (Universidad Politécnica de Valencia, Spain); Bernardo Bernardo-Clemente (Universitat Politècnica de València, Spain)

This paper describes a dual-band aperture array antenna working at K-band (19-22 GHz) and Ka-band (28-31 GHz) using Gap Waveguide concept. The antenna has two feeding layers: the upper layer works at K-band and the lower one at Ka-band. The corporate feeding networks at both layers are rotated 90 degrees to each other to achieve orthogonal linear polarizations. Radiating elements consist of circular apertures located on the top plate of the antenna and fed by two stacked cavities with different diameters for dual frequency operation. Simulated results show both impedance and radiation pattern bandwidth greater than 10% in both bands.

Poster_05.8 ***Dual-Linearly Polarized Unit-Cell and Transmitarray at Ka-Band***

Trung Kien Pham (University of Rennes 1 & IETR, France); Ronan Sauleau (University of Rennes 1, France); Antonio Clemente (CEA-LETI Minatec, France)

This paper presents the design and performance of a narrow-patch wide-band unit-cell used for dual-linearly polarized transmitarray with 3-bits of phase resolution and a small lattice periodicity. The polarizations of transmitting and receiving layers of the unit-cell are orthogonal, leading to a negligible spill-over contribution of feeding source to the co-polarized pattern of the transmitarray. The insertion loss is smaller than 0.5 dB at 29 GHz for all phase states. A dual-linearly polarized transmitarray is designed and analyzed to validate the interleaving technique for dual-polarization operation. A good agreement between single-polarized and dual-polarized transmitarrays is observed, thus validating almost perfect independence of both polarizations.

Poster_05.9 ***Dual-Band Leaky-Wave Lens Antenna for Submillimeter-Wave Heterodyne Instruments***

Sjoerd Bosma (Delft University of Technology, The Netherlands); Maria Alonso-delPino (Jet Propulsion Laboratory, USA); Darwin Blanco (Delft University of Technology, The Netherlands); Jose V Siles (NASA Jet Propulsion Laboratory, USA); Mathieu Choukroun (Jet Propulsion Laboratory, California Institute of Technology, USA); Nuria LLombart (Delft University of Technology, The Netherlands)

In this contribution, we propose an antenna for a dual-band focal plane array (FPA) heterodyne receiver at submillimeter-wave band. The instrument covers the 210-240 GHz and the 500-580 GHz bands on the same receiver FPA to perform cometary observations over the field of view while reducing mass and power. The proposed antenna is composed of a fused silica lens illuminated by a leaky wave waveguide feed. The dual-band leaky wave feed is based on a single-layer Frequency Selective Surface (FSS) which allows to have a quasi- optical system that achieves a footprint of the field of view with overlapped beams and identical beamwidths for both frequency bands. A single pixel antenna prototype is currently being developed.

Poster_05.10 ***X-band Antenna with Enhanced Gain and Sidelobe Suppression***

Paolo Squadrito, Shuai Zhang and Gert Pedersen (Aalborg University, Denmark)

This paper presents a planar circular patch antenna with high gain and sidelobe suppression working in X-band. Two circular slots are employed in this work to increase gain and SLL, by using the superposition of the field radiated from these apertures. A circle of N=10 small vias with nonuniform radius load the antenna cavity in order to excite an additional mode and increase the impedance bandwidth. This antenna shows a realized gain of 15 dBi and an SLL of about -14 dB with a relative impedance bandwidth of 4.5% at expenses of an increased area of the antenna.

Poster_05.11 ***Wideband Ka-Band SATCOM-On-The-Move Antenna Concept: Preliminary Design Study***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); John Kot (Young & Kot Engineering Research, Australia); John Ness (EM Solutions Pty Ltd, Australia)

This paper provides the initial findings of the preliminary design of a 1.2m-diameter SOTM antenna terminal with monopulse tracking able to work over the full combined commercial and military bands at Ka-band.

Poster_05.12 ***Four-Port 5.0-5.3 GHz & 6.8-7.1 GHz Feed-System Design***

John Kot (Young & Kot Engineering Research, Australia); Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia)

A commercial requirement has arisen for an unusual SATCOM C-band feed-system to be used with an offset parabolic reflector. The unconventional operating frequency bands and the requirement for high performance, four-port circular polarization has meant that a bespoke system needed to be designed from scratch.

Poster_05.13 ***Dielectric Embedded Bandpass FSS Linear to Circular Polarisation Transformers***

Sarah Clendinning and Robert Cahill (Queens University Belfast, United Kingdom (Great Britain)); Dmitry E Zelenchuk (Queen's University of Belfast, United Kingdom (Great Britain)); Vincent Fusco (Queen's University Belfast, United Kingdom (Great Britain))

This paper describes a major advance in the design of bandpass anisotropic frequency selective surfaces (FSS) which are engineered to convert linearly polarized (LP) waves into circularly polarized (CP) signals at normal incidence. The thin metal structure operates in transmission mode and is composed of an array of cross slots with unequal arm lengths in the vertical and horizontal directions. We show that a polarisation converter formed by sandwiching the FSS between two flat PTFE substrates can be designed to give a 3dB axial ratio (AR) bandwidth that is significantly larger than the maximum value previously reported for freestanding topologies. The influence of the two supporting dielectric layers on the passband amplitude shaping and phase responses for TE and TM waves is investigated for various dielectric slab thicknesses. Numerical optimisation is then used to exploit this additional design parameter to create a polarization transformer that exhibits a 3dB AR bandwidth of about 8% at a center working frequency of 10.33 GHz. Spectral transmission measurements in the 8-12 GHz band will be presented at the conference.

Poster_05.14 ***Dispersion Analysis of 1-D Periodic Corrugated Metallic Surface Antennas***

Despoina Kampouridou and Alexandros Feresidis (University of Birmingham, United Kingdom (Great Britain))

In this paper a complete dispersion analysis and radiation pattern calculation of 1-D periodically corrugated metallic surfaces is presented for the first time. A full-wave periodic method is presented and performed on a setup of corrugated unit cells. Results are compared to an analytical periodic method that consists in the solution of a transverse resonance equation at the level of the gap openings. Both methods are applied on a corrugated antenna design at 15 GHz and results show a leaky wave radiation effect. The broadside radiation frequency range of the symmetrically fed infinite size antenna can be predicted, considering the beam-splitting condition. The radiation patterns of a practical finite antenna are calculated and are in good agreement with full-wave simulations.

Poster_05.15 ***High Inter-port Isolation Dual Circularly Polarized Modified Franklin Microstrip Antenna***

Sumantra Chaudhuri (IIT Guwahati, India); Rakhesh Singh Kshetrimayum and Ramesh Sonkar (Indian Institute of Technology Guwahati, India)

A dual circularly polarized microstrip antenna with high inter-port isolation is presented. The design comprises of 12 series-fed radiating patch elements separated by phase shifters arranged in a circular fashion with two ports at the feed-lines connected to terminal patches- one each for transmission (Tx) and reception (Rx). The impedance bandwidth of the antenna is 399 MHz (6.727 GHz to 7.126 GHz) and the axial ratio (AR) bandwidth is 330MHz (6.87 GHz to 7.2 GHz). The inter-port isolation is better than 30.8 dB in the entire band and reaches as high as 59.4 dB. Because of its high inter-port isolation and moderate impedance and AR bandwidth, the design is suitable for usage as a DCP antenna for C-band applications.

Poster_05.16 ***Intertwined Inductive Frequency Selective Surface: An Application for Satellite Communications***

Juan Andrés Vásquez Peralvo and Jose Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Jonathan Michael Rigelsford (The University of Sheffield, United Kingdom (Great Britain))

An intertwined tri-band Inductive Frequency Selective Surface (FSS) configured as Cassegrain sub-reflector for Earth to Satellite communication is presented. The sub-reflector is designed to provide linear polarization independency and maximum transparency to electromagnetic waves in K and Ka band at frequencies 16.4-20.4 GHz and 28.2-32.5 GHz respectively, and provide maximum reflectivity to electromagnetic waves in K band at frequencies 23.6-25.4 GHz. The sub-reflector is designed using the Jerusalem cross element along with an intertwined shape. The intertwine shape will reduce the second resonant frequency as well as given more angular stability and maximum bandwidth. The transmission and reflection parameters are shown in all frequencies of interest. Finally, the full structure will be simulated as a flat sub-reflector and placed at the front of horn antennas working at the centre of the frequency bands to compare the radiation pattern against the classical Cassegrain and prime focus configurations. The simulation are carried out using CST Microwave Studio.

Poster_05.17 ***A Study on the Effect of Gas Pressure and Excitation Frequency of a Cylindrical Plasma Antenna on Its Radiation Efficiency***

Fatemeh Sadeghikia, Hamed Mahdikia, Mohammad reza Dorbin, Mahmoud Talafi Noghani and Ali K. Horestani (Aerospace Research Institute, Iran)

This study provides analytical and numerical analysis of the effects of the gas pressure and excitation frequency on the radiation characteristics of a cylindrical plasma antenna. The results show that decreasing the gas pressure leads to a decrease in the plasma loss tangent and an increase in radiation efficiency. It is observed that for the studied case, to achieve the loss tangent smaller than 0.1, the gas pressure in the chamber should be smaller than 18 mTorr. In addition, increasing the excitation frequency decreases the losses and as a result increases the efficiency of the plasma antenna, especially in lower pressures. Therefore, utilizing low pressures and excitation at relatively high frequencies can be applied to achieve desirable radiation efficiency. It is shown that a gas pressure less than 18 mTorr and an excitation frequency over the 1 GHz leads to a radiation efficiency in the order or 90% for our structure.

Poster_05.18 ***Enhancing Radiation Pattern Performance of the Cavity-Backed Lightweight Patch Antenna for Spacecraft Uses***

Arkadiusz Byndas, Mariusz Hofman and Pawel Kabacik (Wroclaw University of Science and Technology, Poland)

This paper summarizes experiences we have gained in the area of optimization radiation pattern for the cavity backed patch antenna. The antenna is to meet user requirements for high data rate links operating between satellites and Earth. The electrical performance has been accomplished and at the same time the antenna mass was very low, whereas antenna robustness against space environment effects have demonstrated outstanding strength.

Poster_05.19 ***Total Atmospheric Attenuation Statistics for LEO Mega-Constellations Operating at Q/V Bands***

Charilaos Kourogiorgas (Science and Technology Facilities Council\RAL Space, United Kingdom (Great Britain)); Apostolos Z. Papafragkakis (National Technical University of Athens, Greece); Pantelis-Daniel Arapoglou (European Space Agency, The Netherlands); Athanasios D. Panagopoulos (National Technical University of Athens, Greece); Spiros Ventouras (STFC Rutherford Appleton Laboratory, United Kingdom (Great Britain))

In this paper, the cumulative statistics of total attenuation induced in mega-constellations employing Low Earth Orbit (LEO) satellites and operating at Q/V bands are investigated. Mega-constellations can offer seamless global coverage employing hundreds or even thousands of satellites. Given the congestion of Ka-band and the need for high data rates, the mega-constellations could operate both for feeder and direct-to-user links at Q/V-bands for downlink and uplink. In this paper, a Walker constellation of 132 satellites is simulated and the total atmospheric attenuation statistics are calculated for three different communication scenarios with the LEO satellites. The scenarios differ on whether the ground station has the ability to track a number of LEO satellites Numerical results for three different locations at Nemea, Greece, Chilbolton, UK and Lagos, Nigeria are presented and commented.

Poster_05.20 ***Validating Weather-Forecast-Driven Propagation Models at Millimeter Waves Using Multisource Ground-Based Radiometric Data***

Luca Milani and Marianna Biscarini (Sapienza University of Rome, Italy); Saverio Di Fabio (CETEMPS, Italy); Klaide De Sanctis (HIMET, Italy); Mario Montopoli (ISAC CNR, Italy); Kevin Magde and George Brost (Air Force Research Laboratory, USA); Frank S. Marzano (Sapienza University of Rome, Italy)

In this work, several sources are used to characterize, in both deterministic and statistical ways, the atmospheric propagation channel in terms of brightness temperature and path attenuation at high frequency bands (such as K- Ka-, V- and W-band). We have used two different models: a weather-forecast-driven 3-dimensional radiative transfer model (RTM) and a stochastic 1-dimensional model (SNEM) with synthetic clouds dataset provided as inputs. We have compared the outputs of such radiative transfer simulations with actual measurements of two co-located microwave radiometers: a humidity and temperature profiler and a Sun-tracking radiometer. The comparisons show satisfactory results and a good agreement among all sources, with some small inaccuracies to be investigated in future works. RTM successfully reproduced correlations between brightness temperature and path attenuation at several frequency bands, confirming the advantage of using weather forecast models combined with physically-based radiative transfer models.

Poster_05.21 ***On Optical Satellite Communication Systems Design: CFLOS Calculation and OGS Selection***

Nikolaos Lyras (National Technical University of Athens, Greece); Charilaos Kourogiorgas (Science and Technology Facilities Council\RAL Space, United Kingdom (Great Britain)); Theodore Kapsis (School of Elec. & Com. Engineering, National Technical University of Athens, Greece); Athanasios D. Panagopoulos (National Technical University of Athens, Greece)

Optical satellite communication systems are severely affected by the cloud coverage. Therefore, for the evaluation of system's availability Cloud Free Line of Sight statistics of the optical ground stations (OGSs) must be estimated. The elevation angles and the altitude of the OGSs should be considered for the accurate prediction and reliable evaluation of the optical satellite network performance. In this paper, new simple engineering expressions for the estimation of CFLOS in terms of the elevation angle of the slant path, the altitude of the OGS, and the CFLOS of the corresponding vertical link are presented. Additionally, a new selection algorithm of the OGSs for the formation of an OGS Network (OGSN) that would achieve a CFLOS threshold but also mitigating the turbulence effects, is proposed. The proposed models are evaluated numerically and some interesting conclusions are drawn.

Poster_05.22 ***Propagation Model for High Altitude Platform Systems Based on Ray Tracing Simulation***

Frank Hsieh (Nokia Bell Labs, USA); Marcin Rybakowski (Nokia, Poland)

Satellites and HAPS can be used as a platform to extend connectivity to remote areas and bring about 5G services to under-served populations. We have conducted ray tracing simulations to study signal propagation from HAPS to ground using maps of Chicago downtown and a suburban residential area. Using the ray tracing data, we developed a simple path loss model to estimate the propagation loss in a combination of free space propagation and terrestrial clutter induced attenuation. The model can be characterized by two environment specific parameters and is applicable to arbitrary vehicle height and elevation angle. We also present in this paper multipath characteristics in suburban and dense urban environments that are useful for fast fading modeling and system design.

Poster_05.23 ***Impact of Water Vapor Attenuation on Low Elevation SatCom Links***

Luciano M Tomaz, Lorenzo Luini and Carlo Capsoni (Politecnico di Milano, Italy)

The water vapor absorption effect cannot be neglected in satellite communication (SatCom) systems operating at higher frequency bands (e.g. W band). It becomes even more significant when it comes to very low elevation angles, such as those characterizing GEO satellites with ground stations at high latitudes, or MEO/LEO satellites. This paper presents some preliminary results on the impact of water vapor attenuation AV at different elevation angles, as well as on scaling AV from zenithal pointing to low elevation angles. The results, obtained from an extensive set of large water vapor content maps, show that the customary cosecant scaling approach is accurate down to 5°. Finally, some preliminary results on the impact of AV on a link to a MEO satellite are also shown.

Poster_05.24 ***SNO Based Optimization for Shaped Beam Reflectarray Antennas***

Alessandro Niccolai and Riccardo Enrico Zich (Politecnico di Milano, Italy); Michele Beccaria and Paola Pirinoli (Politecnico di Torino, Italy)

The design of a shaped beam reflectarray is a challenging issues. The problem can be hardly addressed by deterministic techniques or standard optimization due to the elevated number of design variables and its non-convex nature while can be much easily solved adopting Evolutionary Optimization Algorithms. In particular, in this paper a recently introduced evolutionary approach, named Social Network Optimization (SNO) has been applied to the design of a reduced size shaped beam reflectarray: the obtained numerical results are promising and prove the effectiveness of the adopted method.

Poster_05.25 ***Single Passive Scatters Decoupling Technique for Ultra-High Field Magnetic Resonance Imaging Application***

Masoud S. M. Mollaei (Aalto University, Finland); Anna Hurshkainen (ITMO University, Russia); Constantin Simovski (Aalto University, Finland)

In this report, decoupling conditions between two dipole antennas, created by adding either a single passive dipole or single passive split-loop resonator (SLR), for ultra-high field magnetic resonance imaging (MRI) are compared. In contrast to our previously reported work, the decoupling granted by the dipole is advantageous. We numerically and experimentally demonstrate that parasitic impact of the passive dipole on distributed magnetic field inside the phantom is smaller than that of the passive SLR.

Poster_05.26 ***Indoor 3D Spherical near Field RCS Measurement Facility: Innovative Technique for Positioner Error Correction***

Pierre Massaloux (CESTA, France)

Indoor RCS measurement facilities are usually dedicated to the characterization of only one azimuth cut and one elevation cut of the full spherical RCS target pattern. In order to perform more complete characterizations, a spherical experimental layout has been developed at CEA for indoor Near-Field monostatic RCS assessment [1]. This experimental layout is composed of a 4 meters radius motorized rotating arch (horizontal axis) holding the measurement antennas while the target is located on a mast (polystyrene or Plexiglas) mounted on a rotating positioning system (vertical axis) [2] . The combination of the two rotation capabilities allows full 3D Near-Field monostatic RCS characterization. The major measurement contributors to uncertainty are due to the near field illumination [9], the influence of the mast supporting target under test [8], and the uncertainty due to bearing imperfections of the Roll positioner. This error can create undesired movement along the radial dimension of the test range and corresponding errors in the measurement phase. This paper presents the results obtained after the installation of a hexapod under the roll positioner, allowing correcting the various positioning errors related to the mechanical float, but also to an improper positioning between the positioner roll's center of rotation and the polystyrene mast supporting the target under test.

Poster_05.27 ***An Investigation of the Mutual Coupling and Tuning of a Miniaturized Metamaterial Absorber***

Safiullah Khan (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

This work is related to a metamaterial based microwave absorber design consisting of a single dielectric layer with a rectangular split-ring resonator and a T-type resonator printed on one side and a metal film coating on the other side. The structure is investigated to determine the effect of mutual coupling between the two resonators on the resonance frequencies. Due to the distinct resonance frequencies of the resonators, the absorber can operate in two frequency bands, i.e., 7.82 GHz and 9.65 GHz. Each of the resonance frequencies can be easily controlled by a single parameter without affecting the other. The surface current distributions at both the frequencies are presented and analysed to better understand the absorber behavior. To realize the absorber, a standard WR90 hollow waveguide (X-band) measurement setup is used. Simulation and measurement results show similar trends; differences are discussed.

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Other / Regular Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Mohammad S. Sharawi (Polytechnique Montreal, Canada), Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

15:00 ***Dr. Hans Steyskal: A Tribute to His Life and Technical Accomplishments***

Jeffrey Herd (MIT Lincoln Laboratory, USA)

This paper chronicles the life, career, and technical accomplishments of Dr. Hans Steyskal. His career as an eminent researcher in the field of phased array antennas spanned over 50 years, with significant contributions in the areas of digital beamforming, adaptive pattern synthesis, EM analysis of arrays, and wideband conformal arrays.

15:40 ***THz Antennas - Design, Fabrication and Testing***

Chi Hou Chan (City University of Hong Kong, Hong Kong)

In this paper, we present an overview of Terahertz (THz) antenna research conducted in the State Key Laboratory of Terahertz and Millimeter Waves (City University of Hong Kong). The ever increasing demand for higher speed and larger data volume is driving wireless communications towards the era of Terabit-per-second (Tbps) in the next decade. To reach capacity equality with fiber optics by expanding the operating frequency band into the THz regime, high-gain antennas working at THz frequencies are required. In anticipation of the broad applications of THz in wireless communications, spectroscopy and imaging, we started to build our infrastructure for THz research in 2012. Major equipment was acquired and accessories not commercially available were designed and fabricated in-house or through commercial vendors. Prior to the design of THz antennas, the use of fabrication materials and processes need to be pre-determined. With no exception, the antennas can only be waveguide fed or probe fed with a probe station unless they are used as part of a THz source in on-chip antenna and photoconductive antenna. Limitations imposed by electrical properties of the material, fabrication process and feeding mechanism are circumvented by design innovation and careful tuning of the geometrical parameters. We have laser circuit structuring systems, 3D printers, and micromachining facilities for fabrications of THz antennas working from 0.3 to 1 THz. We also have frequency extender modules from OML and VDI covering the frequency bands up to 1.1 THz. For material characterizations, we have time-domain spectrometers that can go up to 20 THz. Depending on the operating frequency, the designed THz antennas can be fabricated by printed-circuit-board (PCB), 3D printing and micromachining technologies and characterized by our purpose-built near-field or far-field antenna testing platforms. Most of the testing accessories were made in-house by 3D printing while some were fabricated by computer numerical control (CNC) machining via commercial vendors. We have designed low-gain THz antennas that are used as probes for our near-field antenna measurement and imaging platforms. These probes are basically open-ended waveguide (OEWG). The wall thickness of the probe is tapered, making it a pyramidal shape. Three sets of linearly-polarized (LP) probes for 220-325 GHz, 325-500 GHz and 500-750 GHz have been made using CNC machining by VIVATECH. The probe is inserted into a 3D printed absorber to eliminate the ±1dB ripples in the probe radiation pattern due to the reflection from the waveguide flange of the probe. For other polarizations at 0.3 THz, we have designed modification fixtures fabricated by PCB and attached to a pyramidal OEWG fabricated by CNC machining. For high-gain THz antennas, Fresnel zone plate lens antennas fed by a complementary source feed has been reported. The feed, mounted on an OEWG generates a symmetric and equal E- and H-plane radiation patterns. A meta-lens fed by an LP horn that can generate circularly-polarized (CP) radiation has been realized for satellite-to-satellite communications. The measured gain is 24.5 dBic but the 3dB axial ratio bandwidth is only 1.6%. Metasurfaces fed by an LP horn can serve as reflectarrays or transmitarrays, depending on the orientation of the feed horn with respect to the principal axes of the metasurface. The directions of the reflected and transmitted beams can be designed independently. The transmitted beam can also be focused at the focal point for THz imaging. These antennas have been fabricated by PCB technology when operating at no more than 0.3 THz. On the other hand, we can design 0.3 THz lens antennas fabricated by low-cost 3D printers. When fed by an LP horn, the lens can provide either LP or CP far-field radiation or focused beam, depending on the designed phase distributions on the lens aperture. CP radiation has been achieved by incorporating an anisotropic medium, in the form of dielectric grating, integrated with the 3D printed lens. The CP lens has a broadside gain of 30.8 dBic and 3dB axial ratio bandwidth of more than 18.8%. The 1-dB gain bandwidth is 13.3%. We resort to micromachining when 3D printing could not meet our design tolerance. Anomalous radiation characteristics have been realized using metasurfaces fed by diagonal gain horns up to 1.1 THz. Both 1D and 2D focusing beam arrays have been demonstrated. These metasurface lenses can be used in building imaging system with electronic beam steering. Using micromachining, we demonstrated a 2-by-2 magneto-electric dipole array operating at 1 THz with 260 GHz absolute bandwidth. The array has a flat gain of 14 dBi. For THz source generation, we have been working on-chip antennas and photoconductive antennas and some of our recent results will be presented in the conference.

Inv_04 Wed: Inv_04 Invited Session 4

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Other / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Thomas Kuerner (Braunschweig Technical University, Germany), Ronan Sauleau (University of Rennes 1, France)

15:00 ***Classic Electrically Small Antennas Versus in/ On-Body Antennas: Similarities and Differences***

Anja K. Skrivervik (EPFL, Switzerland)

Electrically small antennas (ESAs) have been discussed since the early radio days, when all antennas were small compared to the wavelength. The boom of mobile phones triggered a second wave of intense research activity on these devices, which continues today where virtually everything has a wireless connection. This intense research activity has produced interesting and usefully results on the physical limitations of such antennas, design rules and optimal designs. Since the beginning of the century, the number of medical, sports, or security applications (to name just some of them) requiring implantable or wearable communication devices has grown at a high speed, launching the interest for wearable or implantable ESAs. Many interesting designs have been published to this date, but we only start understanding the fundamentals of such antennas. Neither physical bounds on their radiation characteristics nor optimal designs or design rules are yet available. In this contribution, I will highlight the main similarities and differences between classic ESAs and antennas for wearables and implants, illustrated by practical examples.

15:40 ***Application of L1 Minimization Techniques to near Field-to-Far Field RCS Transformations***

Ivan LaHaie (Integrity Applications Incorporated, USA)

Image-based near field-to-far field transformation (NFFFT) algorithms developed by the authors and their colleagues have gained wide acceptance for their ability to accurately estimate monostatic far field (FF) radar cross-section (RCS) from wideband monostatic near field (NF) measurements. The algorithms implicitly use the reflectivity density model common to synthetic aperture radar (SAR) imaging to derive closed form expressions for transforming NF measurements collected a variety of 1D and 2D complete coordinate surfaces to FF RCS on the corresponding surfaces in the far field. While analytically elegant and computationally efficient, these closed form "conventional" NFFFTs suffer from errors in the predicted FF RCS due "edge effects" from the finite measurement bandwidth and/or truncation of the scan surfaces. The 1D NFFFT algorithms also suffer from errors when the target has appreciable extent perpendicular to the slant range plane. In this paper, we present the use of the basis pursuit denoise (BPDN) L1 minimization technique to mitigate these and other shortcomings of the conventional NFFFT algorithms. The paper begins with a review of the radar reflectivity density model and its role in formulating the conventional image based NFFFTs. This is followed by examples of FF prediction errors due to finite bandwidth edge effects for the particular case of the 1D circular NFFFT (CNFFFT). We then show how interpreting the reflectivity density model as a linear mapping between the (unknown) reflectivity density and the (known) NF measurements allows the NFFFT to be reformulated as an underdetermined linear optimization/prediction problem which can be iteratively solved using BPDN. Finally, we show how this approach can mitigate the errors in the CNFFFT examples shown earlier.

Wednesday, April 3 16:50 - 18:30

CS16 EM Meth Direct & Inv Scatt: CS16 Electromagnetic methods for direct and inverse scattering involving stratified media

Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Alessandro Fedeli (University of Genoa, Italy), Giuseppe Schettini (Roma Tre University, Italy)

16:50 ***Microwave Imaging in Stratified Media: A Multifrequency Inverse-Scattering Approach***

Claudio Estatico, Alessandro Fedeli, Matteo Pastorino and Andrea Randazzo (University of Genoa, Italy)

The problem of reconstructing dielectric structures embedded in stratified media is addressed in this paper. In particular, an inverse-scattering method operating in constant-exponent Lebesgue spaces is adopted for retrieving the dielectric properties of buried objects located in a three-layer medium. This approach, which features a nonlinear modeling of the scattering effects, processes data acquired at multiple frequencies at the same time, for improving the imaging performances. Some preliminary results, obtained with synthetic data, are presented in order to validate the method and assess its reconstruction capabilities in this configuration.

17:10 ***A Multiplicative Regularizer to Incorporate Prior Spatial Data in Microwave Imaging Reconstruction***

Puyan Mojabi and Nozhan Bayat (University of Manitoba, Canada)

We present a multiplicative regularized Gauss-Newton inversion algorithm that is capable of incorporating prior spatial information about the object being imaged. In this approach, in addition to the standard weighted L2 norm total variation multiplicative regularizer, we utilize another regularization term to enforce the available structural information. This algorithm is designed so that it can work with partial (incomplete) prior spatial information.

17:30 ***Shape Estimation in Stratified Media via Inverse Source and Joint Sparsity***

Martina Teresa Bevacqua (Università Mediterranea di Reggio Calabria, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

This contribution tackles with qualitative characterization of objects buried in stratified scenario. To this end, a recently introduced approach, aimed to support reconstruction and based on inverse source and joint sparsity, is tailored to the case of stratified media and of different field polarizations. In particular, the proposed joint sparsity promoting approach is able to take advantage from field polarization diversity by enforcing a coherence amongst the different currents induced by both TE and TM polarized fields.

17:50 ***Perfect Conversion from Surface Wave to Leaky Wave Through Periodic Metasurfaces***

Svetlana Tcvetkova and Sergei Tretyakov (Aalto University, Finland); Stefano Maci (University of Siena, Italy)

We discuss here exact solutions for a lossless and reciprocal surface impedance which ensures full conversion of a single-mode surface wave propagating along the impedance boundary to a single plane leaky-wave propagating along a desired direction in free space above the boundary. In contrast to known approximate realizations of leaky-wave antennas, the optimal surface reactance modulation which is found here ensures the absence of higher-order modes of the Floquet wave expansion. Thus, all the energy carried by the surface wave is used for launching the single plane wave into space, without accumulation of reactive power.

18:10 ***Simulation of Electromagnetic Scattering in a Through-Wall Environment***

Cristina Ponti and Giuseppe Schettini (Roma Tre University, Italy)

In the modelling of electromagnetic scattering in a Through-the-Wall environment large domains made by walls, and sparse targets are involved. Approximated models based on ray-tracing techniques are mostly employed to reduce computer times, although a more accurate response that takes account of all the interactions between walls and targets may be obtained with full-wave methods. In this work, the Cylindrical Wave Approach is employed, as full-wave technique for the modelling of Through-the-wall scenarios. The technique is mainly analytical, as targets with circular cross-section are modelled through expansions into cylindrical waves. However, through suitable rules, it is possible to approximate targets with cross-section of arbitrary shape through an arrangement of smaller circular cross-section cylinders. This may be applied, for example, to the modelling of pieces of furniture, as wall as to introduce further walls in the simulation domain.

Sp_A02 Ant Arr&Systems: Sp_A02 Antenna Arrays and Systems for Space Applications

Space / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Herve Aubert (LAAS, France), Tao Huang (Oxford Space Systems, United Kingdom (Great Britain))

16:50 ***Circularly-Polarized CTS Arrays***

Michele Del Mastro (University of Rennes 1, France); Francesco Foglia Manzillo (CEA-LETI, France); Maciej Smierzchalski (CEA, France); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Pouliguen Philippe (DGA, France); Patrick Potier ((DGA), France); Ronan Sauleau (University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

This paper proposes a novel concept of circularly-polarized continuous transverse stub (CTS) arrays. The structure consists of long radiating slots in a ground plane, fed by overmoded parallel-plate waveguides (PPWs). Two geometrically-polarized modes are launched for achieving circular-polarization (CP). An efficient in-house tool has been developed to assess the capabilities and limitations of such antenna concept. The active reflection coefficient and axial-ratio (AR) are provided together with some design guidelines. The results obtained with our tool have been validated using a full-wave commercial simulation software. We show that the proposed antenna exhibits AR better than 3 dB over a ±45° field of view. Furthermore, the active reflection coefficient is lower than -10 dB over a 55.4% operative bandwidth. The proposed concept is appealing for Ka-band terminals for Satcom applications.

17:10 ***A Low-Profile Low-Cross Polarization Dielectric Dome Antenna for Wide-Scanning Applications***

Erio Gandini (TNO, The Netherlands); Fabrizio Silvestri (Eindhoven University of Technology & Nederlandse Organisatie voor Toegepast- Natuurwetenschappelijk Onderzoek TNO, The Netherlands); Alice Benini (University of Siena, Italy); Giampiero Gerini (TNO - Defence, Security and Safety, The Netherlands); Enrica Martini (Wave Up Srl, Italy); Stefano Maci (University of Siena, Italy); Giovanni Toso (European Space Agency, The Netherlands); Stefania Monni (TNO Defence Security and Safety, The Netherlands)

A dielectric dome antenna design in Ku-band is presented. The dome antenna is based on the combination of a phased array and a dielectric lens with the goal enlarge the field of view of the antenna. In particular, the array is considered to scan up to 60° and the lens is used to enhance the field of view up to 70°. The optimization of the surfaces of the dome is based on a ray-tracing technique and the performance is evaluated using an in-house physical optics code. The size of the dome is minimized to allow its use for a low-drag aeronautical antenna. Experimental results confirm the predicted performance. The cross-polarization is lower than the one of the illuminating array because of the reduced phase difference of the array elements.

17:30 ***Circularly Polarized Active Antenna Array System Calibration for Improved Axial Ratio Systems***

Miguel Salas-Natera (Universidad Politécnica de Madrid, Spain); Ramón Martínez Rodríguez-Osorio (Universidad Politécnica de Madrid); Leandro de Haro y Ariet (Universidad Politécnica de Madrid, Spain); Manuel Sierra Perez (Universidad Politecnica de Madrid, Spain)

This paper presents a novel calibration technique for circularly polarized active antenna array with improved axial ratio and polarization-agile systems. The proposed algorithm deals with the problem of calibration of active antenna arrays, proposing a calibration technique that can be implemented in off-site or on-site process depending on the system calibration and control design. The proposed calibration technique starts with the implementation of a complex circular polarization feeding network with the capability to change the response of each of the polarization circuits with signal attenuators. The expansion of equations of the proposed calibration algorithms is also presented. This algorithms deal with the compensation of mutual coupling effect and together with gain, phase and location errors.

17:50 ***All-metal Dual Frequency RHCP High Gain Antenna for the Extreme Environments of a Potential Europa Lander***

Nacer Chahat (NASA-JPL, Caltech, USA)

A new all-metal dual-frequency RHCP high gain antenna is under development at NASA's Jet Propulsion Laboratory for a potential Europa Lander. The antenna is mainly made of metal so it could survive the harsh environment conditions of Europa (i.e. very low temperature and high radiation and ESD levels). The antenna is flat to meet drastic volume constraints and has efficiencies higher than 80% at both the uplink and downlink X-band Deep Space frequency bands. This antenna is a key component for the potential mission enabling Direct Link to Earth (DTE) without any relying on an Orbiter to relay the data.

18:10 ***Towards Direct Radiating Array Utilization for Satellite Missions***

Theodoros Kaifas and Dimitrios G. Babas (Aristotle University of Thessaloniki, Greece); John Sahalos (Aristotle University of Thessaloniki, Greece and University of Nicosia, Cyprus)

Direct radiating arrays are undisputedly recognized as the final target step in the evolution of the satellite telecommunication antennas. Their performance characteristics are unparalleled but this comes with the cost of high number of controls needed for their implementation. The authors have attacked this problem for a decade now achieving major reduction in the number of controls needed. For example, for 5 to 6 degrees field of view, the decrease was from roughly a thousand to 6 hundred controls - element radiators. Thus achieving 40% reduction and leading the state of the art. After this first stage, a second one is ongoing were designs with arrays of overlapping elements are pursued. In this case, while the initial anticipated number of controls reduction was an additional 20%, in the current work we contribute two indicative high performance Direct Radiating Array designs that achieve an additional 35 to 50% reduction in the number of controls. Thus, the contributed results introduce the Direct Radiating Array implementation into the realm of feasibility since those extremely low number of controls needed are well into the reach of current technology.

F_A01 Antenna Theory: F_A01 Antenna theory, computational and numerical techniques

TOP

Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Manuel Arrebola (Universidad de Oviedo, Spain), Tomasz P Stefanski (Gdansk University of Technology, Poland)

16:50 ***Exact Formulas for the Determination of Antenna Local Phase Center***

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Matteo Albani (University of Siena, Italy)

This paper presents exact formulas for the calculation of antenna local phase center. It will be shown that the knowledge of equivalent current distribution on an arbitrary radiating aperture allows the determination of phase center exact position. We will prove that the transverse coordinate (with respect to the observation direction) of phase center can be interpreted as the electromagnetic barycenter of the electric and magnetic current distributions, whereas (with respect to the observation direction) can be considered the electromagnetic equivalent of the momentum of inertia. Numerical results on the equivalent aperture distribution of a pyramidal horn antenna are presented to validate the technique.

17:10 ***Full-Wave Synthesis of Modulated Metasurface Antennas***

Modeste Bodehou and Christophe Craeye (Université Catholique de Louvain, Belgium); Enrica Martini (Wave Up Srl, Italy); Isabelle Huynen (Université catholique de Louvain, Belgium)

A full-wave synthesis algorithm for modulated metasurface antennas is presented. It is able to provide arbitrary radiation patterns, with any polarization. The algorithm does not use the local periodicity approximation, but is directly based on the electric field integral equation (EFIE). Using Fourier-Bessel basis functions (FBBFs), one can efficiently discretize the surface currents. An inverse problem based on the EFIE is then formulated to derive the surface impedance from the knowledge of the currents. It has been observed that the FBBFs are also more suited than the Zernike basis for the surface impedance discretization. In the case of antenna applications, only the visible part of the surface currents spectrum is known from pattern specifications. This visible part can be combined with the nearfield of the average reactance (SW contribution) to derive the required impedance boundary condition (IBC); this latter is constrained to be anti-Hermitian as required for implementation in the absence of losses. An example of shaped beam design is presented and numerically validated.

17:30 ***Nonlocal and Non-Hermitian Extensions of Transformation Optics***

Massimo Moccia, Giuseppe Castaldi and Vincenzo Galdi (University of Sannio, Italy)

We compactly review a body of recent results dealing with possible extensions of conventional transformation optics which enable the systematic modeling and harnessing of nonlocal and non-Hermitian effects in metamaterials.

17:50 ***Fundamental Performance Bounds for Sub-Region MIMO Antennas***

Casimir Ehrenborg and Mats Gustafsson (Lund University, Sweden)

In modern small antenna applications only a small fraction of the device is dedicated to antenna design. This imposes harsh restrictions on the performance for those antennas. However, the current on the antenna element in a small section of the device induces currents on the other, passive, parts. In this conference contribution a method for studying the fundamental bounds on capacity and mode strength of such configurations is presented. A convex optimization problem for maximal capacity in the current density of the antenna sub-region is formulated and solved semi-analytically. The results are illustrated for a rectangular plate and its sub-regions.

18:10 ***Approaching Q-Factor Bounds by Combining TM and TE Modes on a Cylindrical Shell***

Vit Losenicky, Miloslav Capek and Lukas Jelinek (Czech Technical University in Prague, Czech Republic)

Surface current densities on cylindrical shells are studied in terms of fundamental bounds on Q-factor. It is shown that the optimal current solution is not feasible by means any of practical realization. A solution with the second lowest Q-factor is found using the resonant composition of modes. This current solution is proved to be attainable as a cylindrical helix. Optimal modal composition is studied with respect to cylinder eccentricity and diameter to length ratio. It is shown that a circular cylinder yields a Q-factor close to fundamental bounds, however, the limiting case of a rectangular plate yields only a Q-factor associated with the TM bound. The physical reasons for this behaviour are explained.

CS15 AMTA: UAV-based Ant CS15 AMTA session: UAV-based Antenna Measurements

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Future Applications / Convened Session / Measurements

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Hans-Juergen Steiner (Aeroxess UG, Germany), Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy)

16:50 ***Near-Field Phase Reconstruction for UAV-based Antenna Measurements***

Lorenzo Ciorba (Institute of Electronics, Computer and Telecommunication Engineering (IEIIT-CNR), Torino & Politecnico di Torino, Torino, Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Fabio Paonessa (National Research Council of Italy (CNR - IEIIT), Italy); Stefania Matteoli (Consiglio Nazionale delle Ricerche, Italy); Pietro Bolli (INAF - Osservatorio Astrofisico di Arcetri, Italy); Eloy de Lera Acedo and Nima Razavi Ghods (University of Cambridge, United Kingdom (Great Britain)); Jens Abraham (Norwegian University of Science and Technology, Norway); Edgar Beltrán (Cavendish Laboratory, United Kingdom (Great Britain)); Kristian Zarb Adami (University of Oxford, United Kingdom (Great Britain)); Alessio Magro (University of Malta, Malta); Oscar A. Peverini (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT- CNR), Italy); Giuseppe Addamo (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT-CNR), Italy); Giorgio Giordanengo (Istituto Superiore Mario Boella & Politecnico di Torino, Italy); Marco Righero (LINKS Foundation, Italy); Giuseppe Vecchi (Politecnico di Torino, Italy)

A non-tethered Unmanned Aerial Vehicle equipped with a RF source has been used as a near-field scanner in the VHF band. In this configuration, the source is not phase-locked to the receiver local oscillator/clock. A reference antenna, placed at a proper distance from the antenna-under-test, has thus been exploited to reconstruct the phase. Experimental results at 175 MHz for the central element of the Pre Aperture Array Verification System of the Square Kilometre Array are shown. The comparison with simulations shows very good agreement.

17:10 ***Interference Measurements of a High Power Cable-Bound Unmanned Aerial Vehicle***

Robert Geise (Technische Universität Braunschweig, Germany); Alexander Weiss (University of Braunschweig, Germany); Torsten Fritzel and Rüdiger Strauß (Aeroxess UG, Germany); Fabian T. Faul (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

This contribution describes measurements of possible interference spectra in a high power electrical environment of a large unmanned aerial vehicle as a carrying platform for measurement equipment for electromagnetic fields. The utilized measurement probes are a current monitor probe, which encloses cable structures, and a small loop antenna moved manually around the structure to cover a large space and identify possible maxima of interfering fields. Measurements are performed for several operating flight modi of one rotor, which is mounted on ground but fully operational. The obtained results give a good overview of interference spectra and intensities, which are a valuable basis for a later design of portable measurement equipment to be mounted on such flying platforms.

17:30 ***Monostatic RCS Prediction from Irregularly Distributed Near-Field Samples Using Plane-Wave Field Synthesis***

Ole Neitz (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

We present an approach to accurately determine the monostatic RCS of an object under test, by measuring a set of bistatic near-field scattering data, where it is sufficient to sample the scattered field in a small angular range around the transmitting antenna. This is achieved by solving a field synthesis problem for the incident plane wave with respect to the transmitter locations and using the result to weight the outcome of a series of inverse source problems. By expanding the fields in propagating plane waves on the unit sphere, almost arbitrary scan surfaces can be processed efficiently, including highly irregular ones. Thus, the measurement samples of the scattered field may potentially be collected by the use of unmanned aerial vehicles and it may even become possible to determine the RCS of large stationary outdoor targets. The paper outlines the theory of the algorithm and demonstrates its capabilities by means of simulated and measured near-field data.

17:50 ***Advances in the Development of an Industrial UAV for Large-Scale Near-Field Antenna Measurements***

Torsten Fritzel, Hans-Juergen Steiner and Rüdiger Strauß (Aeroxess UG, Germany)

The use of multi-rotor UAVs for antenna measurements open up breathtaking and new possibilities in outdoor antenna measurements. Commercial off-the-shelf multi-rotor UAVs provide an excellent ground for research and development activities and for proof-of-concept measurements. In this paper key requirements and a concept of an antenna measurement UAV especially designed for large-scale and industrial near-field antenna measurements will be explained concluding with its current development status reached so far.

18:10 ***Advances in Antenna Measurement and Characterization Using Unmanned Aerial Vehicles***

María García Fernández (University of Oviedo, Spain); Yuri Álvarez and Fernando Las-Heras (Universidad de Oviedo, Spain)

Recent developments in unmanned aerial vehicles (UAVs) hardware and antenna measurement postprocessing techniques have fostered the development of in-situ antenna measurements using UAVs. Accurate geo-referring of the measurements is one of the most critical issues faced by these systems in order to increase the upper working frequency limit. In this contribution a novel methodology based on simultaneous acquisition of the near field (NF) amplitude on two measurement surfaces using a dual-probe setup on board the UAV is presented. Thanks to it, acquisition time and measurement uncertainties are greatly reduced. System capabilities have been validated by measuring an offset reflector antenna, comparing the results with measurements at spherical range in anechoic chamber.

C_P17 Propag Vehicul: C_P17 Propagation for vehicular communications

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Cellular Communications / Regular Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Jan M. Kelner (Military University of Technology, Poland), Thomas Kürner (Technische Universität Braunschweig, Germany)

16:50 ***Experimental Investigation of V2I Radio Channel in an Arched Tunnel***

Marwan Yusuf and Emmeric Tanghe (Ghent University, Belgium); Luc Martens (Ghent University - imec, Belgium); Pierre Laly, Davy P Gaillot, Martine Liénard and Pierre Degauque (University of Lille, France); Wout Joseph (Ghent University/IMEC, Belgium)

This paper describes the results of the experimental radio channel sounding campaign performed in an arched road tunnel in Le Havre, France. The co-polar and cross-polar channels measurements are carried out in the closed side lane, while the lane along the center of the tunnel is open to traffic. We investigate the channel characteristics in terms of: path loss, fading distribution, polarization power ratios and delay spread. All these parameters are essential for the deployment of vehicular communication systems inside tunnels. Our results indicate that, while the H-polar channel gain attenuates slower than the V-polar channel due to the geometry of the tunnel, the mean delay spread of the H-polar channel is larger than that of the V-polar channel.

17:10 ***Mobile Satellite Propagation Channels at Ka Band for Railway and Highway Environnement***

Sebastien Rougerie (CNES, France); Jonathan Israel (ONERA - The French Aerospace Lab, France)

The design and assessment of air interfaces for modern Land Mobile satellite systems between 1 and 20 GHz require the use of reference generative propagation channel models. The ITU-R Rec. P.681, based on the enhanced 2-state MIMO model, has been developed and validated thanks to several experimental datasets collected from 2 to 20 GHz in different environments and for various elevation angles. In a previous paper, we present new measurements at 20 GHz, especially in railway and highway environments. This paper will present the results of the processing of these data, and in particular the improvement of the ITU-R Rec. P.681 which will now handle railway and highway environments. Moreover, a discussion is done on the wideband behavior of satellite channel for such frequency.

17:30 ***An Analytical Raytracer for Efficient D2D Path Loss Predictions***

Nils Dreyer (Institute for Communications Technology & TU Braunschweig, Germany); Thomas Kürner (Technische Universität Braunschweig, Germany)

The communication between two devices (D2D) plays an important role for future networks as Internet of Things (IoT) or Intelligent Transport System (ITS). A challenging task is the simulation of the physical layer in highly dynamic networks with plenty of moving devices. Nowadays such simulations are mostly performed using stochastic channel models completely neglecting specific spatial effects. Ray optical path loss predictions (Raytracing), considering 3D building data, are often seen as not suitable for large networks because of its high complexity combined with its long processing time. In this paper we will introduce a novel calculation method that leads to a significant speed up of Raytracing predictions. The approach analytically investigates a scenario and precalculates the visibility between all surfaces. The changing propagation paths of moving devices can be quickly determined even for higher orders of reflection.

17:50 ***Application of Reflecting Panels in Realisation of Antenna Corridor for Train Communications***

Nima Jamaly (Swisscom, Switzerland); Stefan Mauron (Swisscom (Schweiz) AG, Switzerland); Ahmed Kishk (Concordia University, Canada)

At the advent of 5G mobile communication systems, reliable and fast wireless communications for the user equipments onboard a train is crucial. One of the desirable cost-effective solutions is to use dedicated antennas installed along the train tracks. This is known as antenna corridor. Usually, the antenna corridor solution is used in combination with an antenna on the roof-top of the wagon and a repeater plus one (or few) leaky feeder cables inside it. Nevertheless, for certain reasons, it is more desirable to receive signals into the wagon through its window panes directly. The latter causes extra losses due to the wide (i.e., ≈ 90 degrees) arrival angles between incoming waves and the window panes' surface vector. In this paper, we propose to use a passive reflector which is installed alongside the train track to forward the incoming waves towards the wagon. We use a simple 45◦ slanted plane reflector and quantify the reduction it yields in pathloss between an arbitrary transmit antenna and an ideal dual-port dual-polarised isotropic antenna within a selected wagon.

18:10 ***Distributed Massive MIMO Channel Measurements in Urban Vehicular Scenario***

David Löschenbrand (AIT Austrian Institute of Technology GmbH, Austria); Markus Hofer (AIT Austrian Institute of Technology, Austria); Laura Bernadó (Austrian Institute of Technology, Austria); Gerhard Humer (AIT Austrian Institute of Technology GmbH, Austria); Bernhard Schrenk and Stefan Zelenbaba (AIT Austrian Institute of Technology, Austria); Thomas Zemen (AIT Austrian Institute of Technology GmbH, Austria)

We present a measurement framework for rapidly time-varying distributed massive multiple-input multiple-output (MIMO) channels. We introduce a custom-built calibration device to facilitate calibration of multiple transceivers as well as a synchronization structure for distributed massive MIMO arrays. Measurements are performed with two transmit and 32 receive antennas in parallel with 115\,MHz bandwidth and 1\,ms repetition rate at a carrier frequency of 3.52\,GHz. The transmit antennas are mounted on a car moving through an urban environment while the receive antennas are placed on the rooftop of a building. We analyze the measured channel characteristics and the singular value spread over time for collocated and distributed receive antenna setups. Our results show that collocated receiver arrays outperform the distributed ones in terms of the singular value spread for the given scenario.

MT_P02 Propag Exp: MT_P02 Propagation experimental methods and campaigns

TOP

Methods & Tools / Regular Session / Propagation

Room: Oral Sessions: S4-B - Lublin

Chairs: Krzysztof K. Cwalina (Gdansk University of Technology, Poland), Slawomir Hausman (Lodz University of Technology, Poland)

16:50 ***Distributed Spatial Channel Emulation for Virtual Drive Testing Based on Multiple Software-Defined Radios***

Lisa Jäger, Philipp Berlt and Christian Bornkessel (Technische Universität Ilmenau, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

Following a strong trend towards cognitive connected cars, modern automobiles are equipped with a multitude of wireless communication systems. In order to ensure proper functionality, reliability, and resilience of these systems, the development of suitable test facilities and verification methods is of great interest in current research. An established testing method is the concept of channel emulation, in which temporal and spatial characteristics of mobile communications are reconstructed in a lab environment, in order to allow for reproducible and stable test conditions. Under the roof of the Thuringian Center of Innovation in Mobility in Ilmenau, Germany, the virtual road simulation and test area - VISTA was installed and laid out for virtual drive testing. This paper presents a distributed spatial channel emulator, which is based on multiple commercially available software-defined-radio modules and can be deployed in an over-the-air measurement setup. Pursuing a cluster-based measurement concept, it allows for reconstructing essential features of electromagnetic wave propagation in the wireless automotive communication channel. In this paper, the implementation of the distributed channel emulator is described and its feasibility demonstrated in principle.

17:10 ***Quick Overview of Two Years of Measurements with the Alphasat Q-band Satellite Beacon***

Armando Rocha (University of Aveiro & Instituto de Telecomunicações, Portugal); Susana Mota (University of Aveiro & Institute of Telecommunications, Portugal); Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal)

The characterization of the propagation channel at Ka-band and above still needs more experimental campaigns to collect an extensive database to support the development of new models or fine tune available propagation models in all possible geographical sites and climates. The ESA funded Technology Demonstration Payload (TDP5) at Q/V band installed on board of the satellite Alphasat offered a new opportunity to perform large-scale measurements in Europe at 39.402 GHz. The paper reports the major and preliminary results of two years of propagation measurements collected at Aveiro, Portugal. Some static and dynamic statistical aspects of the propagation channel are briefly addressed.

17:30 ***High-order XPD Statistical Properties Assessment for Spectral-efficient Space Ka-band Services***

Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal); Antonio Martellucci (European Space Agency, The Netherlands); Armando Rocha (University of Aveiro & Instituto de Telecomunicações, Portugal); Carlo Riva (Politecnico di Milano, Italy)

Spectral-efficient communication systems, exploiting either frequency-reuse schemes or polarization diversity techniques, rely on the joint characterization of the radiowave propagation channel in what concerns the channel-induced interference, by means of the well-known cross-polarization discrimination (XPD), and attenuation. This characterization lacks of assessment by means

of a reliable and long-term propagation experimental database, establishing the basis for the future modelling efforts of the depolarization effects, especially at frequency-bands higher than the Ku-band, where the bandwidth required for the deployment of innovative multimedia services is available. In this contribution, the past assumptions observed from limited data collected by experiments at Ku-band are evaluated and the current standard models performance is investigated by means of two testing variables that are now proposed. The evidences found are discussed in-line with the requirements of future modelling efforts.

17:50 ***Low Cost Radio Shielding Effectiveness Using Carbonised Wood***

Wilson Conniott (Instituto Politécnico de Leiria, Portugal); Judite Vieira and Silvia Monteiro (Polytechnic Institute of Leiria, Portugal); Rafael F. S. Caldeirinha (Polytechnic Institute of Leiria & Instituto de Telecomunicações, Portugal)

This paper presents recent results on the study of a new electromagnetic shielding techniques for existing building materials based on cross-laminated timber (CLT) at frequencies ranging from 680 MHz to 8 GHz. In particular, CLT bounded with carbonised wood has been studied as a means of controlling Radio Frequency (RF) transparency of such structures in a sandwich manner. Results demonstrate that new electromagnetic shielding techniques based on natural raw materials for application in forest derivatives products can be both efficient and low-cost. Shielding effectiveness of up to 35 dB were observed at key frequency bands, proving its feasibility to applications in Internet of Things (IoT) and 5th Generation (5G) wireless communications. This is sought to contribute to circular economy by providing additional shielding factor from coarse woody debris and, thus, to reduce the carbon footprint in e.g. developed countries.

18:10 ***AlphaSat Dual-Frequency Receiving Station in Rome, Italy: Upgrade of the Ka-band Front-End and Case Study Analysis***

Augusto Marziani (Sapienza University of Rome, Italy); Fernando Consalvi (FUB, Italy); Gianmarco Fusco (Istituto Superiore delle Comunicazione e delle Tecnologie dell'Informazione, Italy); Frank S. Marzano (Sapienza University of Rome, Italy); Carlo Riva (Politecnico di Milano, Italy); Antonio Martellucci (European Space Agency, The Netherlands)

The AlphaSat TDP5 experiment, also now as Aldo Paraboni, is a scientific experiment held by the European Space Agency (ESA) to investigate radio propagation channel in the Ka and Q bands. The AlphaSat satellite was launched in orbit in 2013 and since then several European research group have been monitoring the received beacon signals to model physical effects of the atmosphere on the transmitted electromagnetic field. This article is aimed to describe the AlphaSat receiving station in Rome, focusing on the latest upgrade of the Ka-band receiver. Focused attention will be payed to the new tracking system for the Ka-band receiver and related enhancements of the overall performance. At the end, a case study from the acquired dataset will be analyzed aiming at the effects on the signal due to the atmospheric turbulence and rain.

L_A04 Power Transfer I: L_A04 Wireless Power Transmission and Harvesting I

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Davor Bonefačić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia), Ahmed Kishk (Concordia University, Canada)

16:50 ***Phase ReLock - Localization of RFID Tags by a Moving Robot***

Anastasios Tzitzis, Spyros Megalou, Stavroula Siachalou and Traianos Yioultsis (Aristotle University of Thessaloniki, Greece); Athanasios Kehagias (Aristotle University Thessaloniki, Greece); Emmanouil Tsardoulias (Centre of Research & Technology & Aristotle University of Thessaloniki, Greece); Alexandros Filotheou, Andreas Symeonidis, Loukas Petrou and Antonis G Dimitriou (Aristotle University of Thessaloniki, Greece)

In this work, we propose a prototype method for the localization of RFID tags, by deploying RFID equipment on a robotic platform. The constructed robot is capable to perform Simultaneous Localization (of its own position) and Mapping of the environment and then locate the RFID tags around its path. The proposed method is based on properly treating the measured phase of the backscattered signal by each tag at the reader's antenna, located on top of the robot. More specifically, the measured phase samples are reconstructed, such that the 2pi discontinuities are eliminated. This allows for the formation of an optimization problem, which van can be solved rapidly by standard methods. The proposed method is experimentally compared against the most accurate reported method in prior-art and the same accuracy is preserved. However, the problem is solved more than one order of magnitude faster, allowing for the applicability of the method in real-time inventorying and localization.

17:10 ***Variable Capacitive Antenna Loading for Embedded RFID Sensors***

Giselle Gonzalez (Universitat Politècnica de Catalunya, Spain); Luis Jofre (Universitat Politecnica de Catalunya, Spain); Jordi Romeu (Universitat Politècnica de Catalunya, Spain); Ignasi Cairó (WitekLab, Spain)

In this paper, a self-adaptive folded dipole antenna to work embedded in media with changing physical and chemical properties for RFID applications is proposed. Self-adaptability is provided by taking advantage of the dual-mode behaviour of the folded dipole antenna where variable capacitance diodes are strategically placed to compensate for the change produced in the electromagnetic properties of the embedding medium. The presented antenna has been optimized at 868MHz.

17:30 ***Charge Storage Level Sensor RFID Tag: Impedance Matching and Experimental Characterisation***

Nikta Pournoori (Tampre University of Technology, Finland); Leena Ukkonen and Lauri Sydänheimo (Tampere University of Technology, Finland); Toni Björninen (Tampere University & BioMediTech Institute, Finland)

We present an RF energy harvesting system where two distinct passive UHF RFID microchips provide different tag IDs to detect low and high states of the harvester's charge storage. This enables the backend system to acknowledge when the harvesting system is ready for advanced power consuming operations. Overall, we were able to read the separate IDs of the tag at the distance of 3 m from an RFID reader that is emitting the regulated EIRP of 3.28 W and charging harvester's storage capacitor to 0.625 V through 8.7 dBi harvesting antenna.

17:50 ***Read-Range Estimation of UHF-RFID Tags Placed Inside Metal Pipes***

Marcos R. Pino (Universidad de Oviedo, Spain); Andrea Michel (University of Pisa, Italy); Guillermo Alvarez Narciandi (University of Oviedo, Spain); Paolo Nepa (University of Pisa, Italy)

In some application scenarios, the detection of UHF RFID tags used to identify objects can not be estimated by using conventional propagation models. In this paper, a propagation model of a UHF RFID signal is analyzed when the tag is placed inside metal structures like drill pipes and aluminum rolls. Theoretical considerations have been discussed to give practical guidelines when a tagged metal pipe is interrogated by a commercial UHF RFID reader.

18:10 ***Fingerprinting Localization of RFID Tags with Real-Time Performance-Assessment, Using a Moving Robot***

Spyros Megalou, Anastasios Tzitzis, Stavroula Siachalou and Traianos Yioultsis (Aristotle University of Thessaloniki, Greece); John Sahalos (Aristotle University of Thessaloniki, GR, Thessaloniki, Greece & University of Nicosia, CY, Nicosia, Cyprus); Emmanouil Tsardoulias (Centre of Research & Technology & Aristotle University of Thessaloniki, Greece); Alexandros Filotheou, Andreas Symeonidis and Loukas Petrou (Aristotle University of Thessaloniki, Greece); Aggelos Bletsas (Technical University of Crete, Greece); Antonis G Dimitriou (Aristotle University of Thessaloniki, Greece)

This work is focused on unmanned inventorying and localization, by deploying an RFID-equipped autonomous robot. The robot is able to perform Simultaneous Localization and Mapping (SLAM), thanks to its optical sensors. As the robot moves inside the target area, it continuously interrogates all RFID tags within range. Passive RFID tags, placed at known locations, are used for the estimation of the locations of the target tags, by properly manipulating the measured backscattered power. The proposed method does not depend on the location of the reader, but only on the locations of the reference tags. Hence, positioning-errors related to SLAM are not accumulated. Mobility of the robot ensures rich collection of measurements. We propose a method for dynamic, real-time configuration of the parameters of the fingerprinting algorithm and real-time evaluation of the localization error of the unknown tags. This is achieved by treating the reference tags as target tags. Thanks to this property, we further exploit mobility of the robot, repeating inventorying and localization in areas, where poor performance is initially recorded. Measurements indicate a mean error of 18cm, with standard deviation of 11cm, deploying a single antenna.

R_A03 Array Ant: R_A03 Array antennas, antenna systems and architectures

TOP

Radars / Regular Session / Antennas

Room: Oral Sessions: S4-D - Bytom

Chairs: Raphael Gillard (IETR & INSA, France), Mario Orefice (Politecnico di Torino, Italy)

16:50 ***On the Design of a Circularly Polarized Microstrip Antenna Array for CubeSat in the Ka-Band***

Giulia Buttazzoni, Francesca Pelusi and Roberto Vescovo (University of Trieste, Italy)

This paper describes the preliminary phases of the design of a planar antenna array to be mounted on a face of a CubeSat operating in the Ka-frequency band. In order to compensate the high attenuation of the millimeter-waves, the antenna is required to be circularly polarized, and the final array is composed of subarrays of sequentially rotated square microstrip patches with truncated corners. In particular, two candidate geometries are presented for the subarray, which improve a prototype previously realized at the University of Trieste. Then, the performances of three possible configurations for the final array are evaluated.

17:10 ***Analytic-Based Synthesis of Tiled Arrays***

Nicola Anselmi, Paolo Rocca and Andrea Massa (University of Trento, Italy)

The partitioning of phased arrays into tiles reduces significantly the costs of the whole system and allows an easy assembly and maintenance of the antenna. Because of the deployment of phased arrays in many civil radar and communication systems is becoming very attractive, due to the electronic steering and reconfigurability, efficient synthesis techniques able to effectively

optimize the tiling configuration and the feeding network control points are of great interest in the antenna community. This work aims at reviewing recent synthesis methods for tiled arrays, focusing on analytic-based techniques, and exploiting recent mathematical tiling theory for an efficient synthesis of tiled arrays.

17:30 ***Review of CPM for Array Clustering - A Unified Approach to Subarraying***

Giorgio Gottardi (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Andrea Massa (University of Trento, Italy)

In this paper, a sub-arraying method which jointly deals with amplitudes and phases of the element excitations for reducing the number of control points (namely, amplifiers and phase shifters) is presented. A synthesis tool based on an excitation matching strategy for jointly defining the subarray architecture and the complex subarray excitations is developed. The k-means algorithm is employed to determine the compromise solution which minimize the least square distance with respect to the reference excitations.

17:50 ***Beam-Steerable Phased Antenna Arrays Using Substrate-Integrated Waveguide Phase Shifters***

Cheng Zhao (The 50th Research Institute of China Electronics Technology Group Corporation, P.R. China); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

The design of two beam-steerable phased antenna arrays using one-stage and two-stage substrate-integrated waveguide (SIW) phase shifters is proposed in this paper. The phase shifting capability of the SIW phase shifter is achieved by introducing movable metal posts placed in air slots at the input and output ports of the SIW. For illustration, the two antenna arrays are designed for a resonance frequency of 7.6 GHz using finite-element simulations. For each antenna array, the beam steering is achieved through adjusting the lateral positions of the metal posts in the air slots. Scanning over -8.30 degree to +8.30 degree and -13.80 degree to +13.80 degree is achieved with a steady gain for the one-stage and two-stage realizations, respectively.

18:10 ***Optimizing Antenna Arrays Using Periodic Structure Loading***

Christos Kolitsidas (Ericsson, Sweden); Petros Bantavis (Universite de Rennes 1, France); Lars Jonsson (KTH Royal Institute of Technology, Sweden); George Kyriacou (Democritus University of Thrace, Greece)

Wideband antenna arrays will play an important role in future wireless communication networks due to their ability to support multiple wireless communication systems simultaneously. In this work the utilization of periodic structure loading on wideband antenna arrays is explored. The periodic structural loading is applied to two different arrays a Vivaldi array and a strongly coupled dipole array - SCDA. The constructed arrays along with measured performance are presented.

H_P01 Propag Experiment: H_P01 Propagation Experimental Methods and Campaigns

TOP

High Data-rate Transfer / Regular Session / Propagation

Room: Oral Sessions: G1- Gniezno

Chairs: Wout Joseph (Ghent University/IMEC, Belgium), Cezary Ziolkowski (Military University of Technology, Poland)

16:50 ***Rural Path Loss Measurements and Models for a Fixed Wireless Access TD-LTE Network at 3.7 GHz***

Nektarios Moraitis (National Technical University of Athens & Institute of Communications and Computers Systems, Greece); Demosthenes Vouyioukas (University of the Aegean, Greece); Angelina Gkioni and Spyridon Louvros (Mobile Cloud & Network Services - MCNS, Cyprus)

This paper examines the validity and applicability of different path loss models, based on an extensive measurement campaign in a rural environment at 3.7 GHz (3GPP band 43) for line-of-sight (LOS) conditions. The measurements were carried out using a commercial fixed wireless access (FWA) network operating with Time-Division Long Term Evolution (TD-LTE) configuration. From the path loss analysis, not all of the examined models are appropriate to describe accurately the expected losses. The close-in, WINNER II, and 3GPP/ITU-R models present the best performance. On the other hand, the Extended Hata model is not accurate for the specific area since it over-predicts path loss. Finally, from the statistical analysis the shadow fading is approximated by the Lognormal distribution with zero mean and a standard deviation of 5.8 dB. An almost excellent fit is achieved regardless of the dissimilar propagation conditions in the specific area.

17:10 ***High-Efficiency Wideband Millimeter-Wave Channel Sounder System***

Jing Li, Peize Zhang, Chen Yu, Haiming Wang and Wei Hong (Southeast University, P.R. China)

For outdoor millimeter-wave channel measurement, a new wideband single input and single output channel sounder system with rotatable high-gain horn antennas is presented. This system operates at various millimeter wave frequencies of up to 40 GHz with signal bandwidth of 500 MHz. Two GPS disciplined Rubidium (Rb) clocks are utilized for frequency and timing synchronization. Adding an external power amplifier at the transmitter and an external low noise amplifier at the receiver enables long distance channel measurement in outdoor environments. A rapid measurement method is presented to improve data capturing efficiency together with automatic measurement software. Channel measurement campaigns at 27.5 and 39.5 GHz are conducted in an outdoor-to-indoor scenario. And experimental results are finally analyzed.

17:30 ***Measurements in a Real Data Centre at 300 GHz and Recent Results***

Johannes M. Eckhardt, Tobias Doeker, Sebastian Rey and Thomas Kürner (Technische Universität Braunschweig, Germany)

In this paper a measurement campaign in a real Data Centre at 300 GHz and recent results are presented. The measurements are performed with a UWB sub-mmWave channel sounder and classified in general characterisation, top-of-rack and intra-rack measurements. The individual measurement setups as well as the methodology are explained. In a first step, the measurements are evaluated regarding the path attenuation, the power delay profile (PDP) and the power angular spectrum (PAS). The PDP as well as the PAS give comprehensible results, which are explained by the scenario's geometry. The path attenuation shows reasonable results compared to the free space path loss and demonstrates that wireless communication at 300 GHz in a Data Centre is possible.

17:50 ***Large-scale Parameter Estimation in Channel Sounding with Limited Dynamic Range***

Aki Karttunen and Katsuyuki Haneda (Aalto University, Finland)

In this paper, we examine large-scale parameter (LSP) estimates for spatio-temporal mobile radio channels in the case when the measurement dynamic range is too poor to derive the LSPs for all the measurement locations. Conventionally the LSPs are derived with, e.g., 20 dB dynamic range from the strongest detected multipath component (MPC), but such a measurement dynamic range cannot be guaranteed in all measurements as some of them suffer from large path loss (PL) and/or variation due to shadow fading (SF). We will show that the LSPs, specifically PL, SF, delay spread (DS), and angular spread (AS), can be considered as incomplete data. Incomplete data can be described either by a maximum or a minimum value (or both) when the measurements are with poor dynamic range. We show that the incomplete data should be taken into account in deriving the LSP statistics using the maximum likelihood estimation (MLE) rather than omitted as ``outage''. Outdoor-to-indoor (O2I) measurements at the 14-14.5 GHz range are used as an example.

18:10 ***A Four-Year Variability Study for Ka- And Q-band Slant Path Propagation Experiments in Madrid***

Domingo Pimienta-del-Valle (Universidad Politécnica de Madrid, Spain); Pedro Garcia-del-Pino (Universidad Politecnica de Madrid, Spain); Jose M Riera (Universidad Politécnica de Madrid, Spain); Gustavo Siles (Universidad Privada Boliviana, Bolivia)

In satellite propagation, variability (the fluctuations of certain parameter or phenomenon over time with respect to its average behavior) is assessed by using some statistical variable such as its variance over the years. In overall, there are few reports on rainfall and attenuation variability and only very few on fade dynamics, due to the need of experimental data for a long period of time with a high availability (a hard task to achieve) to produce meaningful results. Moreover, most of these reports are focused in the Ka-band. Having data with a high availability (higher than 97 %) for a concurrent period of 4 years in Madrid for KA-SAT (19.680 GHz) and Alphasat (39.402 GHz) propagation experiments, an study of the variability of rainfall rate, excess attenuation and fade and inter-fade number of events is carried out in this paper. The results show a high variability of some parameters.

MT_M02 Ant Meas: MT_M02 General antenna measurements

TOP

Methods & Tools / Regular Session / Measurements

Room: Oral Sessions: G2- Opole

Chairs: Brett Walkenhorst (NSI-MI Technologies, USA), Werner Wiesbeck (Karlsruhe Institute of Technology, Germany)

16:50 ***Comparative Analysis of Spherical Near-Field Automotive Antenna Measurement Facilities***

Muhammad Ehtisham Asghar, Frank Wollenschläger and Christian Bornkessel (Technische Universität Ilmenau, Germany); Andreas Griesche (Antenna Technology Center (Europe), ATC GmbH, Itzehoe, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

The comparison of measurement facilities is an important instrument to verify measurement accuracy and to study limitations resulting from the different specialized measurement approaches. A rigorous comparison campaign has been conducted for two automotive antenna measurement facilities located in Germany, namely the Virtual Road Simulation and Test Area (VISTA) at the Thuringian Center of Innovation in Mobility at Technische Universitaet Ilmenau, and Antenna Technology Center (Europe) ATC GmbH, Itzehoe. These facilities deploy spherical near-field antenna measurement techniques in anechoic and semi- anechoic environment, respectively, to conduct antenna measurements for diverse wireless transmission standards ranging in frequency from 70 to 6000 MHz. Measured realized gain radiation pattern and similarity coefficient are the parameters used for the comparison. The results reveal a convincingly good conformity of the two facilities for a variety of measurements.

17:10 ***Measuring a 5G Millimeter-Wave Device's Spherical Coverage***

Brett Walkenhorst (NSI-MI Technologies, USA); Prasadh Ramachandran (Keysight Technologies, Finland)

A new over-the-air (OTA) metric called "spherical coverage" is being discussed in 3GPP. The concept is to test the ability of a device to reliably form beams in any direction, offering connectivity in any orientation and polarization. In this paper, we analyze the effectiveness of various test environments for testing spherical coverage at millimeter-wave frequencies for 5G devices.

17:30 ***Non-Invasive Radiation Pattern Characterisation of an Ultra-Wideband Antenna for Antenna-On-Vehicle Collision Avoidance Applications***

Tian Hong Loh (UK, National Physical Laboratory, United Kingdom (Great Britain)); David Cheadle and Divya Unnikrishnan (National Physical Laboratory, United Kingdom (Great Britain))

This paper presents a study on non-invasive radiation pattern characterisations of an ultra-wideband (UWB) antenna for integration into an antenna-on-vehicle platform for collision avoidance applications. The measured operational frequency range of the UWB antenna under test (AUT) is found to be between 3.5 GHz and 10 GHz. A comparison was made between its radiation profiles at 6.49 GHz while standalone, with a metallic housing and with a pseudo-real vehicle ground platform. All measurements are made in an anechoic chamber. A non-invasive opto-electric field sensor system was employed to minimize distortion of the antenna pattern. The results show that the problem of minimising the effects towards antenna radiation pattern due to proximity effects and vehicle platform is far from trivial.

17:50 ***The Effects of a Generator's Active Input Reflection Coefficient in Antenna Gain Measurements***

Kyriakos Kaslis, Olav Breinbjerg and Jeppe Nielsen (Technical University of Denmark, Denmark)

The problem of determining the reflection coefficient of a generator while it is operating is being tackled in this paper, with emphasis placed on both theory and practical applications. Two particular methods are investigated which are, relatively, simple to analyze and implement. It is shown that they have a close agreement despite the widely different procedure by which they approach the same issue. Additionally, the criticality of the generator active input reflection coefficient in determining the gain of an antenna using the gain substitution technique is shown, highlighting the importance to calculate it.

18:10 ***Far Field Evaluation from Undersampled near Field Measurements Using Numerically Built Basis Functions***

Lorenzo Ciorba (Institute of Electronics, Computer and Telecommunication Engineering (IEIIT-CNR), Torino & Politecnico di Torino, Torino, Italy); Giorgio Giordanengo (Istituto Superiore Mario Boella & Politecnico di Torino, Italy); Marco Righero (LINKS Foundation, Italy); Giuseppe Vecchi (Politecnico di Torino, Italy)

We show experimental results on evaluating the Far-Field (FF) pattern from measured Near-Field (NF) samples of a 8GHz reflector antenna, where a radical undersampling on the data is applied. We reach an accuracy comparable to other standard methods. The key point is the use of additional information about the geometry of the antenna to numerically build a set of basis functions which are used to express the measured samples. Once approximated with these functions, the field can be easily evaluated on a finer grid of points or in the FF. The method can be easily applied with measurements performed on non-canonical grids.

B_M01 Other Meas: B_M01 Other Measurement Topics

TOP

Biomedical / Regular Session / Measurements

Room: Oral Sessions: A2- Ustka

Chairs: Robin Augustine (Uppsala University, Sweden), Ali Zamani (The University of Queensland, Australia)

16:50 ***Electromagnetic Based Fatty Liver Detection Using Machine Learning***

Aida Brankovic, Ali Zamani and Amin Abbosh (The University of Queensland, Australia)

Fatty Liver Disease (FLD) is becoming prevalent disease in nowadays lifestyle while not being restricted to individuals with uncontrolled alcohol intake. Early diagnosis can prevent advanced irreversible liver disease, liver failure and ultimately can save lives. Computational methods reduce the operator dependability and hence improve diagnostic reliability. Most of these methods are based on automated analysis of Computed Tomography (CT), Ultrasound (US), and Magnetic Resonance (MRI) images. Besides the high costs and harmful radiation involved in the conventional imaging tools, the outcome of the automated imaging strongly depends on the image quality. To address the shortcomings of current tools, we propose an electromagnetic system, including an antenna operating across the band 0.4-1 GHz as a data acquisition device and a supervised Machine Learning (ML) framework to learn an inferring model for FLD directly from collected data. This paper reports the system configuration, ML problem setup and the obtained results, which show an accuracy of more than 97% for the simulated torso model.

17:10 ***Sensor Antenna for Dielectric Constant Measurement of Materials in Contact with the Structure***

Hossein Saghlatoon, Rashid Mirzavand, Mohammad Mahdi Honari and Pedram Mousavi (University of Alberta, Canada)

This paper presents a sensor antenna for dielectric constant measurement of materials in direct contact with the structure while the radiation characteristics of the antenna are not degraded. This is achieved by parasitically loading the antenna while the samples are placed on the parasitic element. The dielectric constant measurement range is studied and the equivalent circuit of the antenna is proposed. The agreement between the simulation and measurement proves the practicality of the proposed system.

17:30 ***Three Dimensional Acoustic Contrast Source Inversion Method***

Xiaoqian Song, Maokun Li, Fan Yang and Shenheng Xu (Tsinghua University, P.R. China); Aria Abubakar (Schlumberger-Doll Research, USA)

In this paper, we extend the improved acoustic multiplicative regularized contrast source inversion (MR-CSI) method to three dimensions. There are mainly three problems that need to be solved. Firstly, due to the increase in unknowns, the ill-posedness of the problem is more severe, and it would be more complicated in reconstructing object of interest. Secondly, the field distribution changes from two dimensions to three dimensions, that is, the field would also propagate along vertical direction, so the problem is more nonlinear. Besides, the investigated domain also expands from two to three dimensions, so the computational cost and storage increases greatly. For the first two problems, our solution is to choose a stronger regularization to reduce the uncertainty of the solution. And we also use FFT acceleration to reduce the computational time and storage space. Numerical results show that the three-dimensional improved acoustic MR-CSI method can well reconstruct acoustic parameters of the target.

17:50 ***Preliminary Assessment of the Origin of Spurious Magnetic Effects in Magnetic Nanoparticle Enhanced Microwave Imaging***

Ovidio Mario Bucci (University of Naples, Italy); Gennaro Bellizzi (University of Naples Federico II, Italy); Sandra Costanzo (University of Calabria, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Giuseppe Di Massa (University of Calabria, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy)

Magnetic nanoparticles enhanced microwave imaging has a great potential in breast cancer diagnosis. In fact, thanks to the non-magnetic nature of human issues, it would allow high specificity diagnosis already at early stages. To meet this goal, a crucial requirement is to design and built an imaging device free of spurious magnetic effects, which could hide the useful signal due to the magnetic nanoparticles targeted to the tumor or induce false positives. In particular, spurious effect -free measurements must be ensured up to the precision required to gather the very low useful signal. In this communication, we report the preliminary results on an investigation aimed to assess the origin of the possible spurious magnetic signals, in order to devise effective actions for their elimination.

18:10 ***Estimation of Average Absorption Cross Section of a Skin Phantom in a mm-Wave Reverberation Chamber***

Reza Aminzadeh (Ghent University-imec, Belgium); Jérôme Sol (INSA Rennes, France); Philippe Besnier (IETR, France); Maxim Zhadobov (University of RENNES 1, France); Luc Martens (Ghent University - imec, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

The average absorption cross section (AACS) of a human skin-equivalent phantom is calculated under diffuse exposure in a reverberation chamber (RC) in the mm-wave band. Two methods are proposed, in the first method the quality factor of the RC is evaluated in the spectral domain. The second method is based on the theory of room electromagnetics and fitting power delay profile to obtain reverberation time. Similar results were obtained for both methods. AACS values of 225±0.048 cm^2 and 225±0.017 cm^2 were derived for the first and second method, respectively. These results are in good agreement.

Thursday, April 4

Thursday, April 4 8:40 - 12:30

CS34 Next-gen Comp EM: CS34 Fundamental challenges and novel methodologies in the next-generation computational electromagnetics

TOP

Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Elizabeth Bleszynski (Monopole Resesarch, USA), Francesca Vipiana (Politecnico di Torino, Italy)

8:40 ***Grid-robust Discretization of Integral Equations in the Electromagnetic Scattering Analysis of Homogeneous Targets with Geometric Singularities***

Eduard Ubeda and Ivan Sekulic (Universitat Politècnica de Catalunya (UPC), Spain); Juan M. Rius (Universitat Politècnica de Catalunya, Spain)

The conventional method-of-moment schemes of discretization for the scattering analysis of homogeneous targets, perfectly conducting or dielectric, rely on edge-based basis functions. This restricts the modelling of the targets to conformal meshes, with all adjacent facets sharing one single edge. Prior to the electromagnetic analysis, edge-based schemes require the execution of edge search algorithms in order to establish the set of interior edges of the mesh. On the other hand, flaws in the mesh generation may give rise to an incomplete identification of the interior edges and a wrong modelling of the currents. Recently introduced facet-based schemes of discretization of surface integral equations, with volumetric testing, have exhibited improved accuracy in the analysis of targets with geometric singularities. Since facet-based schemes ignore by definition edges, they are better suited than the edge-based schemes for the robust analysis of slightly defective meshes, e.g. with unconnected vertices or misaligned edges.

9:00 ***Compressed Projection Bases for Model-Order Reduction of Multiport Microwave Components Using FEM***

Martyna Mul (Gdańsk University of Technology, Poland); Damian Szypulski (Gdansk University of Technology, Poland); Grzegorz Fotyga (Gdańsk University of Technology, Poland); Michal Mrozowski (IEEE, USA)

This paper describes a projection basis compression technique for generating compact reduced-order models (ROM) in the FE analysis of microwave devices. In this approach, redundancy is removed from the projection basis by means of an orthogonal decomposition technique applied to the projected system of linear equations. Compression allows the size of the reduced-order model to be kept as small as possible without compromising the ROM's accuracy. The effectiveness of the basis compression technique, taking into account memory and time consumption, as well as the size of the resultant ROM, is discussed for both global and local model-order reduction schemes.

9:20 ***Non-singular Laplacian Representations of Kernels of Electromagnetic Integral Equations and Its Application to Analytical Evaluation of Volume Integral Equation Matrix Elements***

Elizabeth Bleszynski (Monopole Resesarch, USA); Marek Bleszynski, Dr (Monopole Resaearch, USA); Thomas Jaroszewicz (Monopole Research, USA)

We present extensions and selected applications and of the method of evaluating matrix elements of electromagnetic volume integral equations with the help of suitably constructed Laplacian-type representations of singular kernels (Green functions) appearing in electromagnetic volume and surface integral equations. The method consists of representing the singular kernels (Green functions) in terms of a generalized Laplacian operator acting on some auxiliary functions. Such representations allows us, by using Gauss divergence theorem, to convert volumetric and surface integrals representing matrix elements to integrals always involving only non-singular integrands. The task of of finding particular Laplacian representation of different kernels amounts to solving appropriate ordinary or partial inhomogeneous differential equations. We discuss a particular application of the method in analytical evaluation of matrix elements of the volume integral equation which employs two different Laplacian representations of the integral equation kernels, one applied to reduction of volume integrals over tetrahedrons to surface integrals over tetrahedra faces and the second one reducing surface integrals over tetrahedra faces to line integrals over tetrahedra edges. We also derive analytical expressions for the resulting line integrals given in terms of elementary functions.

9:40 ***An Inverse Equivalent Surface Current Solver with Zero-Field Enforcement by Left-Hand Side Calderón Projection***

Jonas Kornprobst, Raimund A. M. Mauermayer, Emre Kilic and Thomas F. Eibert (Technical University of Munich, Germany)

The inverse source problem of near-field antenna measurements is often formulated in terms of unknown equivalent electric and magnetic surface current densities. Exploiting just the constraints for the radiated field exterior to a closed Huygens surface results in ambiguous equivalent sources due to the excitation of non-radiating currents during the solution process. Therefore, enforcing the zero-field or Love side condition for the suppression of non-radiating currents based on a left-hand side preconditioner in the form of a Calderón projector is proposed. Transformation results based on realistic measurements demonstrate the effectiveness of this approach.

10:00 ***Efficient Simulation of Metasurfaces Comprising of Truncated Periodic or Quasi-periodic Structures***

Raj Mittra (Penn State University, USA); Nathawut Homsup (Electrical and Computer Engineering, University of Central Florid, USA); Abdelkhalek Nasri (Research Unit of Mechatronic Systems and Signals, National Engineering School of Carthage, Tunisia); Yang Su (Electrical and Computer Engineering, University of Waterloo, Canada)

This paper describes several techniques for enhancing the computational efficiency of Metasurface (MS) modeling when the geometry of the MS is either a truncated periodic structure or it is quasi-periodic, with its elements varying slowly along the surface. The quasi-periodic MS is used to introduce a phase (and amplitude) taper in the transmitted, reflected, or propagating wave interacting with the MS. The three key approaches proposed in this paper are based on using: (a) macro-basis functions for matrix-size reduction; (b) effective medium to replace the MS element; GPU to speed up the generation of multilayer Green's function and associated MoM matrix computation

10:20 Coffee Break

10:50 ***Hybrid Integration Scheme for the Evaluation of the Gradient of the Green's Function***

Javier Rivero and Francesca Vipiana (Politecnico di Torino, Italy); Donald Wilton (University of Houston, USA); William Johnson (Private Consultant, USA)

In this paper we propose to combined both well-known schemes to evaluate strongly near-singular integrals, such as in the Method of Moment (MoM) discretization of the Magnetic Field Integral Equation (MFIE). The method is relatively simple to implement, first, a subtraction of the singularity \1/R^3\ is applied. The remaining integrand is treated via an appropriate variable transformation. The method is numerically validated for static and dynamic kernels arising in the MFIE.

11:10 ***DDM-Assisted Analysis of Large Scale Composite Problems***

Víctor Martín (Universidad de Extremadura, Spain); Diego M. Solís (University of Vigo, Spain); David Larios (Universidad de Extremadura, Spain); Jose M. Taboada and Luis Landesa (University of Extremadura, Spain); José Rodríguez and Fernando Obelleiro (University of Vigo, Spain)

A tear-and-interconnect surface integral equation (SIE) domain decomposition (DD) preconditioner is applied to the electromagnetic solution of realistic large-scale problems including multi-scale features. The paper focuses especially on complex, realistic radiation problems and composite penetrable objects, such as those found in the context of electromagnetic compatibility (EMC) studies or in the field of nanoplasmonic applications. A set of well-posed numerical examples will demonstrate the ability of this approach to improve, or even enable, convergence in such kind of realistic applications.

11:30 ***Hierarchical Implementation of the Analytical Singularity Evaluation Technique***

Denis Tihon (Université Catholique de Louvain & ICTEAM Institute, Belgium); Christophe Craeye (Université Catholique de Louvain, Belgium)

Using the Method of Moments, the computation of the near-field interactions requires to evaluate 4D singular integrals. Recently, a method has been proposed to compute these integrals fully analytically, rapidly providing accurate results. In this paper, we reformulate the analytical technique to highlight the different intermediate results that are involved in the full procedure. We show that, by storing and reusing intermediate results, the evaluation of the singular integrals is accelerated by several orders of magnitudes.

11:50 ***Low Frequency Stable Integral Equation Method for Electromagnetic Scattering of Perfect Conductors and Dielectrics***

Felipe Vico (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Bataller and Eva Antonino-Daviu (Universitat Politècnica de València, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain)

In this paper we present an integral formulation for the calculation of scattering electromagnetic waves in presence of both perfect conductors and dielectrics. The integral formulation is of the second kind, therefore it is immune to high density mesh breakdown, and is stable in low frequency. The formulation uses the electric field as unknown. The resulting integral equation has no spurious resonances. The only drawback of the formulation is that the scattered magnetic field cannot be recovered in a stable way.

12:10 ***A Uniform Asymptotic Solution for the Diffraction by an Arbitrary-Angled Wedge Coated by Lossy DNG Metamaterials: The Case of Normal Incidence***

Gianluca Gennarelli (IREA-CNR, Italy); Giovanni Riccio (University of Salerno, Italy)

The diffraction problem involving an arbitrary-angled perfectly conducting wedge that is coated by a lossy metamaterial slab is solved in the case of plane waves at normal incidence. The solution works in the context of the uniform theory of diffraction and is obtained by means of an analytical procedure that is based on the use of electric and magnetic equivalent surface currents evaluated under the physical optics approximation. The expressions of the diffraction coefficients are manageable since they are in closed form and contain the geometrical optics response of the structure and the transition function of the uniform theory of diffraction. The corresponding diffracted field is able to compensate the geometrical optics discontinuities at the shadow boundaries.

Thursday, April 4 8:40 - 10:20

Sp_A01 Reflect Arrays: Sp_A01 Reflect Arrays and Transmit Arrays

TOP

Space / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Andrea Neto (Delft University of Technology, The Netherlands), Min Zhou (TICRA, Denmark)

8:40 ***Dual Ka-Band Multiple Beam Reflector Antenna for Western European Coverage***

Salvador Mercader-Pellicer (Heriot-Watt University, United Kingdom (Great Britain)); Francesco Rigobello (University of Padova, Italy); George Goussetis (Heriot-Watt University, United Kingdom (Great Britain)); Louis Dufour (Large Space Structures, Germany); Daniele Bresciani (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France); Nelson Fonseca (European Space Agency, The Netherlands)

This paper presents a dual-band multiple beam reflector antenna for a Western European coverage. The dual configuration comprises a wire grid sub-reflector and a polarising main reflector that converts the linearly polarised incidence into circular polarisation with orthogonality between bands. The good performance of the wire grid and the polarising main reflector ensure far-field axial ratio values at the -3 dB region below 1 dB on average without any previous optimisation.

9:00 ***Reflectarray Design to Generate Two Beams per Feed on Arbitrary Shaped Surface by VRT***

Rafael Florencio (Universidad de Sevilla, Spain); Alvaro Somolinos (University of Alcala, Spain); Ivan Gonzalez (Universidad de Alcala, Spain); Felipe Cátedra (University of Alcala, Spain); Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Rafael R. Boix (University of Seville, Spain)

A design technique has been proposed to generate two closely spaced beams in orthogonal circular polarization using the variable rotation technique (VRT) in reflectarrays printed on arbitrary shaped surfaces fed by a single dual circular polarized (CP) horn. The proposed reflectarray cell for VRT is made of a conductive cross printed on a grounded dielectric. A 1.8-meter offset parabolic reflectarray has been designed to generate six beams in circular polarization with three dual-CP feed-horns, with very promising results for multi spot beam satellite antennas in Ka-band.

9:20 ***Improved Bandwidth and Gain Selectivity in Reflectarray Antennas by Using SIW Elements***

Eduardo Carrasco (Universidad Politecnica de Madrid, Spain); Jiawei Zang (Beijing Institute of Technology, P.R. China); Alejandro Alvarez-Melcon (Technical University of Cartagena, Spain); Juan Sebastián Gomez-Diaz (University of California, Davis, USA)

This contribution proposes to improve the response of reflectarray antennas based in aperture-coupled substrate integrated waveguides (SIW) by properly implementing additional slots to the original configuration. By optimizing the number, length and position of rectangular slots, an important improvement in the bandwidth of the reflectarray element can be achieved, while a true-time delay (TTD) is also kept by adjusting the length of the SIW. This strategy also allows to have a sharp response of the gain in terms of the frequency. The replacement of microstrip lines by a SIW allows low losses when the frequency increases, low profile and confinement of back radiation. With this kind of cells, the bandwidth for a 3-dB gain variation can be larger than 20% with gain selectivity of at least 18 dB. This features can be interesting in a wide variation of applications, where a frequency-selective channel is required to avoid interference.

9:40 ***Ultra-wide Beam Scanning Using a Conformal Transmit-array for Ka-band***

André Arraiano (Instituto Telecomunicações, Instituto Superior Técnico, Portugal); Sergio Matos (Instituto Universitário de Lisboa, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal); Nelson Fonseca (European Space Agency, The Netherlands)

A conformal cylindrical transmit-array (TA) for ultra-wide mechanical beam steering is presented. The curved design allows to overcome the effective aperture size reduction caused by the beam tilt - intrinsic to all types of planar arrays. This design must also deal with the aberrations caused by feed displacement relative to the TA focus. Instead of using the usual unifocal approach, the TA phase correction was designed to have two pseudo-foci. In this way, the intrinsic phase error caused by feed displacement can be smeared among all beams improving the overall scanning performance of the antenna. The TA is composed of a collection of curved 5-layer stacked patches designed for the Ka-band uplink (30 GHz). The aperture has 215x150 mm in plane dimensions and height variation of 37 mm. The presented solution provides a 28.9 dBi maximum gain and scanning range up to 80º within 3.9 dB scan loss, which far exceeds the scanning performance of conventional planar TA.

10:00 ***Deployable One-Meter Reflectarray for 6U-Class CubeSats***

Nacer Chahat and Ellen Thiel (NASA-JPL, Caltech, USA); Manan Arya (NASA JPL / Caltech, USA); Jonathan Sauder (NASA-JPL / Caltech, USA); Thomas Cwik (NASA-JPL, Caltech, USA)

This paper describes the development of a 1-m deployable reflectarray antenna which is designed to fit in a 6U (10×20×30cm3) class CubeSats. This antenna was designed for a potential Raincube Follow-on mission, that could potentially follow the success of the precipitation radar Raincube. It deploys into a 98.6cm × 82.1cm flat reflector. This antenna provides a gain of 48.2-dBi and an aperture efficiency of 46%. It consists of a cassegrain reflectarray using a total of 14 deployable panels, a telescoping feed and subreflector.

Thursday, April 4 8:40 - 12:30

CS18 AMTA: Post Processing CS18 AMTA session: Post Processing Techniques in Antenna Measurements

TOP

Future Applications / Convened Session / Measurements

Room: Oral Sessions: S3-A – Gdansk

Chairs: Jeffrey Guerrieri (National Institute of Standards and Technology, USA), Francesco Saccardi (Microwave Vision Italy, Italy)

8:40 ***Probe-Corrected Near-Field to Far-Field Transformation Using Multiple Spherical Wave Expansions***

Fernando Rodríguez Varela (Universidad Politécnica de Madrid, Spain); Belen Galocha (Universidad Politecnica de Madrid, Spain); Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Near-field to far-field transformations constitute a powerful antenna characterization technique for near-field measurement scenarios. In this paper a near-field to far-field transformation technique based on multiple spherical wave expansions is presented. Thanks to its iterative matrix inversion nature, the approach performs the transformation of fields measured on arbitrary surfaces. Also, irregular sampling schemes can be incorporated. The proposed algorithm is based on modelling the antenna fields with not one, but several spherical wave expansions distributed over its geometry. Due to the high number of spherical wave expansions, their truncation number can be arbitrarily reduced. Working with expansions of low order allows to incorporate the probe correction in the transformation in a very simple way, accepting any type of probe and orientation. Only the probe far-field pattern is used, thus working with its full spherical wave expansion is avoided. The algorithm is validated using simulated field data as well as measurements of real antennas.

9:00 ***Antenna Measurement and Diagnostics Processing Techniques Using Unmanned Aerial Vehicles***

María García Fernández (University of Oviedo, Spain); Yuri Álvarez and Fernando Las-Heras (Universidad de Oviedo, Spain)

In-situ antenna measurements using unmanned aerial vehicles (UAVs) has become a research topic of great interest thanks to recent developments in UAV hardware and antenna measurement post-processing techniques for arbitrary geometry acquisition domains. Improvements in UAV positioning and geo-referring systems have enabled in-situ antenna measurements in the near field (NF) region of the Antenna Under Test (AUT). These NF measurements can be post-processed for antenna diagnostics and for radiation pattern evaluation. This contribution focuses on the analysis and comparison of post-processing techniques for in-situ antenna measurement using amplitude-only information, and the impact of the NF measurement domain in the post-processed results, namely aperture fields and radiation pattern. Two iterative phase retrieval techniques are compared using an offset reflector antenna as AUT.

9:20 ***Investigation on Diversity Effects for Phaseless Near-Field Far-Field Transformations***

Josef Knapp (Technische Universität München, Germany); Alexander Paulus (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

Phase retrieval algorithms for phaseless near-field measurements are known to benefit from diversity in a measurement setup. A numerical reconstruction method is utilized to find the number of independent measurement samples in a phaseless NF antenna measurement setup. Certain magnitude and phase difference measurement samples can be linearly reconstructed from previous phaseless measurements. The reconstruction is possible if the corresponding bilinear form for the new sample is linearly dependent from the bilinear forms corresponding to the previous measurement samples. Any linearly independent bilinear form corresponds to an independent measurement value. It is shown that the diversity in the measurements is continuously increasing with an increasing number of measurement distances until a saturation distance is reached. Furthermore, it is shown that the far-field magnitudes can be approximately reconstructed by the linear reconstruction procedure from magnitude- only NF measurements. The approximation error decreases if more NF measurement distances are considered.

9:40 ***Validation of the Fully Probe Corrected Translated-SWE Algorithm for Spherical near Field Offset Measurements with Minimum Sampling***

Francesco Saccardi (Microwave Vision Italy, Italy); Francesca Mioc (Consultant, Switzerland); Andrea Giacomini (Microwave Vision Italy, Italy); Per Iversen (Orbit/FR, USA); Lars Foged (Microwave Vision Italy, Italy)

The Translated Spherical Wave Expansion (TSWE) is a very effective Near-Field-to-Far-Field (NF/FF) transformation tool for down-sampled Spherical Near Field (SNF) measurements with offset Antenna Under Test (AUT). As presented in previous publications, such tool is well suited to characterize antennas mounted on complex structures such as cars, satellites and airplanes. In case of electrically small probes and/or small AUT-probe view angles the TSWE can be accurately applied without compensating for the probe effect. Instead, in case of more complex probes, the measured signal is affected by an averaging effect that should be compensated to ensure a good accuracy. In this paper the TSWE technique with full probe correction capabilities is validated considering measurements of a standard gain horn performed at several frequencies. The horn has been intentionally displaced in an offset configuration and measured in SNF geometry with a first order probe and two different wideband higher-order antennas as probe.

10:00 ***Effect of the Test Zone Field on the Radiation Characteristics of Antennas***

Thomas M Gemmer and Dirk Heberling (RWTH Aachen University, Germany)

Undesired diffractions or reflections within an antenna measurement chamber interfere with the desired signal causing a deviation from the ideal Test Zone Field (TZF). The resulting non-ideal field causes an error in the measured parameters of an antenna under test. In order to analyse the frequency-dependent error caused by the TZF in a Compact Antenna Test Range (CATR), an evaluation method is introduced which is based on spherical wave expansion. To generate the TZF data, a full-wave technique is applied on the reflector model of the CATR approximating the real existing TZF. Three measured antennas which differ in size and directivity are investigated and the corresponding differences are evaluated using the equivalent-extraneous-error-signal level. It is demonstrated that test zone field compensation has to be applied in order to enable high-accuracy antenna measurements and to provide additional design possibilities of measurement ranges.

10:20 Coffee Break

10:50 ***Reduced Sampling in NF Antenna Measurement Using Numerical Defined Expansion Functions***

Maria Alberica Saporetti, Francesco Saccardi and Lars Foged (Microwave Vision Italy, Italy); Jan Zackrisson (RUAG Space AB, Sweden); Marco Righero (LINKS Foundation, Italy); Giorgio Giordanengo (Istituto Superiore Mario Boella & Politecnico di Torino, Italy); Giuseppe Vecchi (Politecnico di Torino, Italy); Damiano Trenta (European Space Agency, ESTEC, Italy)

This paper presents an advanced RF test methodology for time efficient antenna testing. The measured field is projected over precomputed basis functions obtained with simulations of the antenna platform using fast ray-tracing methods. The source antenna is treated as a black box. As the number of basis functions is significantly reduced with respect to the Nyquist criteria, the number of NF measurement points is equally reduced, or down-sampled, leading to a significant saving in overall measurement time. The new methodology performs faster antenna measurements, while maintaining a certain level of confidence. It can be directly implemented, without hardware changes in existing spherical near field measurements range. In this paper we introduce the new methodology for the first time. The method has been validated using actual measurements of a small X-band antenna on a large satellite mock-up. The new methodology achieves a sampling reduction, or down sampling factor of 5-9.

11:10 ***Reconstruction of the Far Field Radiated by an Offset Mounted Volumetric AUT from Nonredundant Spherical Spiral Near-Field Measurements***

Francesco D'Agostino, Flaminio Ferrara, Claudio Gennarelli, Rocco Guerriero and Massimo Migliozzi (University of Salerno, Italy)

This work provides an experimental assessment of the near to far-field transformation (NTFFT) with spherical spiral scan, which properly accounts for the mounting of a volumetric AUT in offset configuration. Such a NTFFT, based on the nonredundant sampling representations of electromagnetic fields using a spherical modelling of the antenna under test (AUT), requires the same number of near-field (NF) spiral data when the AUT is mounted both in onset and offset configuration, because this number depends only on the area of the modelling sphere. The reported experimental results prove the effectiveness of the developed NTFFT and of the related two-dimensional optimal sampling interpolation scheme used to reconstruct, from the spiral NF samples, the NF data at the raster grid points required by the classical spherical NTFFT.

11:30 ***Fast Synthesis of Scattered Waveform Generators in the near Field***

Amedeo Capozzoli, Claudio Curcio and Angelo Liseno (Università di Napoli Federico II, Italy)

We deal with an approach, based on the Singular Value Optimization (SVO) technique, for the synthesis of array-based generators of near-field complex waveforms. The approach selects the grid wherein enforcing the design specifications and the radiator locations to control the ill-conditioning associated to the determination of the array excitation coefficients. Following the SVO optimization, the array coefficients are determined by a Singular Value Decomposition (SVD). Numerical results are provided for the synthesis of the near-field scattered by a perfectly conducting sphere illuminated by an elementary dipole.

11:50 ***Spherical Wave Expansion Applied to the Measured Radiation Patterns of Automotive Antennas in the Installed State in the GHz Range***

Frank Wollenschläger (Technische Universität Ilmenau, Germany); Lars Foged (Microwave Vision Italy, Italy); Muhammad Ehtisham Asghar and Christian Bornkessel (Technische Universität Ilmenau, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

Automotive near-field antenna measurement ranges face certain limitations in combination with conventional transformation methods. These limitations can be successfully overcome by advanced post-processing methods. Several tests were conducted to verify the feasibility of the translated spherical wave expansion for automotive antenna measurements. These measurements were compared to standard transformation algorithms as well as reference measurements, and were found to yield promising results.

12:10 ***Examination of the Effectiveness of Mode Orthogonalisation and Filtering for Scattering Suppression in Antenna Measurements Through Computational Electromagnetic Simulation***

Zhengrong Tian (National Physical Laboratory & NPL, United Kingdom (Great Britain)); Stuart F Gregson (Queen Mary, University of London, United Kingdom (Great Britain))

Reflections in antenna measurement ranges comprise the most significant term within the overall uncertainty budget. For over a decade, a frequency domain mode filtering based technique has been utilized to reduce range reflections. Although this technique has been extensively examined and verified empirically by measurements, relatively little verification by computational electromagnetic simulation is available in the open literature. In this paper, we developed an efficient electromagnetic (CEM) model of the measurement configuration, using a full-wave CEM solver. The purpose of this is to construct a truth-model to provide a firm basis for detailed quantitative examination of the scattering suppression technique. The modelling technique is discussed in detail and initial results are presented which show very good agreement between the "true" far-field pattern of the antenna in free space and that of the far-field of the antenna when perturbed with the presence of a scatterer and applying the scattering suppression process.

CS39 Signal Processing for Advanced EM: CS39 Signal Processing Techniques for Advanced Electromagnetics Synthesis, Analysis and Measurements

TOP

Future Applications / Convened Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Nicola Anselmi (University of Trento, Italy), Andrea Massa (University of Trento, Italy)

8:40 ***Low-Cost Dual-Band E-shaped Patch Antenna for Energy Harvesting Applications Using Grey Wolf Optimizer***

Achilles D. Boursianis, Sotirios Goudos and Traianos Yioultsis (Aristotle University of Thessaloniki, Greece); Katherine Siakavara (Aristotle University, Greece)

Radio frequency energy harvesting is a well promising technique for proactive energy replenishment in next-generation wireless networks. To meet the challenging requirements of power consumption in future wireless networks, new antennas have to be designed. In this paper, we refer to the antenna design problem for energy harvesting applications, by introducing a low-cost dual-band E-shaped patch antenna that operates at LoRaWAN and mobile communication frequency bands. The designed antenna is tuned at two different frequencies (866MHz, 937MHz) at a satisfactory bandwidth for both frequency bands.

9:00 ***A Synthesis Technique for the Beam Scanning with Aperiodic Arrays***

Giulia Buttazzoni and Roberto Vescovo (University of Trieste, Italy)

This paper proposes a method to find the optimal positions of the elements of a linear aperiodic array, with the aim of performing the scanning of the beam in an angular region of interest, by phase-only control. A recently proposed Gaussian approach is adopted, in which the desired pencil beam is approximated by a Gaussian function. By a proper formulation of the problem, the element positions are synthesized in closed form, so as to perform a continuous beam scanning by suitably modifying only the excitation phases. The amplitude distribution of the array elements is uniform, so that the feeding network is simple to realize, and the mutual coupling effects are reduced.

9:20 ***DOA Estimation in 4D Linear Arrays with Unidirectional Phase Center Motion Using Sparse Signal Reconstruction***

Feng Yang (University of Electronic Science and Technology of China & University of Electronic Science and Technology of China (UESTC), P.R. China); Shiwen Yang (University of Electronic Science and Technology of China (UESTC), P.R. China); Yikai Chen (University of Electronic Science and Technology of China, P.R. China)

A novel DOA estimation method in 4D arrays with unidirectional phase center motion (UPCM) using sparse signal reconstruction is proposed in this paper. In order to reduce the influence of time modulation on noise as far as possible, a unidirectional phase center motion (UPCM) with one element turned on over a period is used. Moreover, the l1-norm with singular value decomposition (SVD) is used to reduce the computation loads in the sparse signal reconstruction algorithm. An 8-elememnt 4D linear array is used to validate the proposed method. By comparing with other methods, simulation results show that the better performance can be obtained using the proposed method

9:40 ***Resolution Capabilities of the DBIM-TwIST Algorithm in Microwave Imaging***

Ziwen Guo, Syed Ahsan, Olympia Karadima, Ioannis Sotiriou and Panagiotis Kosmas (King's College London, United Kingdom (Great Britain))

We investigate resolution capabilities of adaptive thresholding methods in the context of iterative microwave imaging algorithms. Our test cases involve two closely located cylindrical targets of high dielectric contrast with respect to the background in a microwave tomography setup simulated in CST. We apply a distorted Born iterative method (DBIM), and compare a two-step iterative shrinkage thresholding (TwIST) implementation with a conventional conjugate gradient least squares (CGLS) method as linear solvers at each DBIM iteration. Our results demonstrate that applying the TwIST approach can resolve the two closely-located targets much more accurately than the CGLS under identical settings in the DBIM algorithm.

10:00 ***Compressed Sensing Applied to Non-Ideal Microwave Measurements in Metal Enclosures***

Johan Winges (Chalmers University of Technology, Sweden); Livia Cerullo (Chalmers University of Technology, Sweden); Thomas Rylander, Tomas McKelvey and Mats Viberg (Chalmers University of Technology, Sweden)

Compressed sensing can make use of a priori information in the sense that its dictionary may be constructed for an expected object of particular size and shape, should the application deal with the detection and positioning of exactly such expected objects. Here, we test such a compressed-sensing approach on measurements that include objects that are foreign to the dictionary. It is found that the compressed-sensing approach shows reasonable performance that degrades gracefully as the measurement region is contaminated by dielectric objects that are foreign to the dictionary, where the degradation also becomes more severe as more dielectric material is present in the measurement region due to mutual interactions not accounted for by the dictionary.

10:20 Coffee Break

10:50 ***Towards a Generic Model for MU-MIMO Analysis Including Mutual Coupling and Multipath Effects***

Navid Amani and Henk Wymeersch (Chalmers University of Technology, Sweden); Ulf Johannsen and A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands); Marianna Ivashina (Chalmers University of Technology, Sweden); Rob Maaskant (CHALMERS, Sweden)

A network model which accounts for antenna mutual coupling and multipath effects in a wireless channel is proposed as a tool to qualitatively evaluate the performance of a multi-user multiple-input multiple-output (MU-MIMO) system. The system performance is assessed when a zero-forcing (ZF) beamformed conventional uniform linear array (ULA) and a sparse array are employed as one sector of a base station antenna (BSA) in a single-cell network. It is shown that highly correlated user equipments (UEs) in a line-of-sight (LOS) scenario can be decorrelated to some extents, by a scattering environment in a non-line-of-sight (NLOS) scenario. This occurs due to increase of the spatial variation by a multipath effect. Furthermore, in both environments a sparse array

realized by an increased interelement spacing is also capable for correlation reduction among users due to the narrow beams.

11:10 ***Efficient Evaluation of Energy Focusing Based on Eigen-Beamforming***

Thomas Pairon and Claude Oestges (Université Catholique de Louvain, Belgium); Maxime Drouguet (Université catholique de Louvain, Belgium); Christophe Craeye (Université Catholique de Louvain, Belgium)

We provide an efficient Method-of-Moments analysis of 2D fields radiated in a typical indoor environment which is applied to the wireless power transfer from a multiple-antenna access point to multiple devices. These simulations allow the computation of the correlation matrix obtained at the access point array when several devices are active. Power focusing capabilities from the same array are then analyzed, including multipath effects. This technique is based on the eigen-analysis of the correlation matrix measured at the access point and presents similarities with time reversal.

11:30 ***Antenna Near-Field Interpolation Using Matrix Completion***

Benjamin Fuchs (University of Rennes 1 - IETR, France); Laurent Le Coq (University of Rennes 1 & IETR, France); Marco Donald Migliore (University of Cassino, Italy)

We propose to formulate the problem of interpolating the antenna near field as a matrix completion one. It amounts to look for the simplest field distribution that fits a set of randomly measured data, which is a reasonable assumption in absence of a priori knowledge on the radiating structure. Experimental results of antenna near field interpolation and the derived far field computation show that the proposed approach could be an interesting first step towards the development of fast antenna characterization procedures.

11:50 ***Near-Field Reconstruction Using Aperture Probe Correction Technique for mm-Wave Devices***

Johan Lundgren, Jakob Helander and Mats Gustafsson (Lund University, Sweden)

Accurate, efficient and robust measurement techniques of the near-field are important for applications ranging from nondestructive testing of structural components to electromagnetic field exposure assessment of everyday devices. This work presents, a near-field reconstruction technique suitable for devices operating around millimeter wave (30-300 GHz). The technique is used to estimate field values and power density values at an arbitrary plane in the near-field. Two measurements, one of a device under test and one of a small aperture as a calibration measurement, are required to obtain calibrated values and a third measurement of a known antenna is needed in order to obtain absolute calibrated values. The technique utilizes an inverse scattering formulation, where equivalent source currents on a pre-defined surface - representing the radiating aperture of the device under test - are constructed by means of the truncated singular value decomposition method. These currents are then used to generate and propagate the electromagnetic fields to an arbitrary surface, in this work a plane, and further compute the fields and power density. Measurement data are obtained through a planar scan of a 60 GHz standard gain horn antenna, and results are presented and compared with simulations to provide a benchmark case. Good agreement can be observed between the measured and simulated results.

12:10 ***Planar Arrays Diagnosis Through Phaseless Measurements: A Compressive-Sensing-Inspired Approach***

Roberta Palmeri (Università Mediterranea of Reggio Calabria, Italy); Andrea Francesco Morabito (University Mediterranea of Reggio Calabria, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)

A sparsity-promoting technique for the diagnosis of faulty elements in planar array antennas from amplitude-only far-field measurements is presented and assessed. By profitably exploiting the Compressive Sensing theory as well as a proper relaxation of the involved constraints, the diagnosis is cast as a Convex Programming problem. A rule of thumb about the minimum number of needed measurements in order to achieve a satisfactory fitting between reference and reconstructed data is also given.

CS20 ISAP: Asian Ant&Prop CS20 ISAP session: Recent Advances in Asian Antennas and Propagation Research

TOP

Cellular Communications / Convened Session / Antennas

Room: Oral Sessions: S4-A - Poznan

Chairs: Jiro Hirokawa (Tokyo Institute of Technology, Japan), Ronan Sauleau (University of Rennes 1, France)

8:40 ***60-GHz 2D Scan Phased Transmitarray with High Gain and Low Profile***

Peng-Yu Feng (UESTC, P.R. China); Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China)

Due to the restricted transmit power and high propagation loss, highly directional antennas are urgently required in 60-GHz frequency band. In this paper, a low-loss transmitarray antenna (TAA) fed by a 6×6 phased array antenna (PAA) for high-gain conical beam scanning is proposed at 60 GHz. The TAA element is with the arrow-shaped metallic pattern in the middle layer and two polarizers in the upper and bottom layers. The PAA feed element is the printed patch antenna with equivalent metallic cavity, showing an advantage of ease of integration with the control circuits. The proposed PAA-fed TAA features a peak simulated gain of 29.89 dBi in the broadside direction, corresponding to the aperture efficiency of 53.9%, together with a narrow conical beam scanning with a ~2 dB beam crossover. Furthermore, the gain degradations caused by the surface waves on the PAA feed are analyzed in detail, providing some guidance for the PAA feed design.

9:00 ***Dual-Polarized Ring-Slot 5G Millimeter-Wave Antenna and Array Based on Metal Frame for Mobile Phone Applications***

Shengjie Wu, Anping Zhao and Zhouyou Ren (Shenzhen Sunway Communication Co., Ltd, P.R. China)

In this paper, a dual-polarized ring-slot 5G millimeter-wave antenna and its array are proposed. The antenna consists of a cavity-backed ring-slot and two micro-strip feeding branches which are mutually orthogonal. The ±45 degree dual-polarized modes are obtained by coupled feeding the ring-slot with the two feeding branches. The -10dB impedance bandwidth of the proposed antenna is from 27.5GHz to 28.35GHz. The realized gain is 4.86dBi and difference between the co- and cross-polarized level is better than 15dB at 28GHz. For the 1×8 linear array composed of the antenna element, the realized gain and side lobe level of the array in the two polarized modes are pretty good, when the scanning angle varies from 0 to 50 degrees. The proposed antenna array can be integrated with the metal frame of handset devices, which can achieve good end-fire radiation at the same time.

9:20 ***A MMW Reconfigurable Antenna with Switched Beams Using Functional Materials***

Hang Wong and Qing-Yi Guo (City University of Hong Kong, Hong Kong); Laure Huitema (Xlim Laboratory, France); Aurelian Crunteanu (XLIM, CNRS/ University of Limoges, France)

This paper introduces a novel reconfigurable antenna with switched beams by using integrated phase-change material (PCM). Two PCM GeTe-based parasitic patches considered as switchable elements between amorphous and crystalline states are applied to operate with a driven patch radiator. The proposed antenna achieves three switched beams at 0°, 20° and 60° with respect to the broadside direction with realized gains of 7 dBi at 30 GHz. Obtained result shows that the proposed technique is effective to control the tilted beam angle of the antenna by the amorphous-to-crystalline activation of the GeTe patch which can be realized by an optical source, making the antenna simple and compact without extra bias circuit. Hence, the antenna is suitable for millimeter-wave applications.

9:40 ***Circularly Polarized Multi-beam Transmitarray Antenna Using Metasurface***

Chang-Hyun Lee, Viet Hoang, Sang Wook Chi, Sun-Gyu Lee and Jeong Hae Lee (Hongik University, Korea)

This paper presents a circularly polarized quad-beam transmitarray antenna using metasurface. A unit cell of metasurface based on the Jerusalem cross-shaped patch is miniaturized and optimized through equivalent circuit analysis and its performance is further verified through generalized sheet transition conditions. The 4 layered metasurface is a 17 x 17 array of unit cells at the operation frequency of 5.8GHz. The principle of superposition was used to simply obtain quad-beam. Finally, a low profile transmitarray antenna with 0.2 of F/D was designed by choosing the feed antenna with the optimum gain. The designed transmitarray antenna with quad-beam has the peak gain of 12.1 dBic, and the aperture efficiency and 1 dB gain bandwidth were found to be 30.7% and 3.5%~5.5% at four beams, respectively.

10:00 ***Ultra Thin Triple-Layer Square Slot Element for Conformal Transmitarray Design***

Lizhao Song (University of Technology Sydney, Australia); Peiyuan Qin (University of Technology, Sydney, Australia); Y Jay Guo (University of Technology Sydney, Australia)

A triple-layer transmitarray element at 25 GHz is presented in this paper. The element consists of three layers of identical square slots. The entire thickness of the element is 0.508 mm which is equal to 0.043 wavelength in the free space at 25 GHz. Despite of the very thin feature of the element, a full transmission phase range of 360° can be achieved with a maximum 3.8 dB loss. The element is applied to a curved transmitarray conformal to a cylindrical surface. A peak gain of 19.6 dBi at 25.5GHz is realized.

10:20 Coffee Break

10:50 ***Path Loss Model in Crowded Indoor Environments Considering Multiple Human Body Shadowing of Multipath at 4.7 GHz and 66.5 GHz***

Mitsuki Nakamura (NTT Corporation, Japan); Motoharu Sasaki (NTT Access Network Service Systems Laboratories, Japan); Wataru Yamada (Nippon Telegraph and Telephone Cooporation, Japan); Yasushi Takatori (NTT Network Innovation Laboratories, Japan)

In this paper, we report the propagation loss estimation model in the congested environment and also show the estimation formula to make it possible to derive the estimation result easily. We obtained propagation loss characteristics in the 4.7 GHz and 66.5 GHz bands around the Kamioka station ticket gate, which is an indoor congested environment. The RMS error of the calculation result of the propagation loss estimation formula proposed by the authors and the measured value improved by about 1 dB on average as compared with the free space loss and the RMS error of the measured value. The propagation loss estimation formula proposed by the authors can be said to be able to estimate the propagation loss characteristics with high accuracy even in indoor environments.

11:10 ***Recent Progress in Metasurface Antennas Using Characteristic Mode Analysis***

Feng Han Lin, Teng Li and Zhi Ning Chen (National University of Singapore, Singapore)
This paper reviews the recent progress in metasurface (MTS) antennas using characteristic mode analysis (CMA), including the modeling, modal analysis, modal excitation, modal manipulation, and modal synthesis of metasurfaces. The characteristics, operating mechanisms, and functions of MTS antennas based on the combinations of multiple modes are reviewed and summarized. The unique technical merits of MTS antennas are addressed.

11:30 ***Optically Transparent 1-D EBG Antenna Using Sub-Skin Depth Thin-Film Alloy in the Ka-Band***

Jae-Yeong Lee (Pohand Unversity of Science and Technology, Korea); Sohyeon Jung and Youngno Youn (Pohang University of Science and Technology, Korea); Junho Park (Pohang University of Science & Technology, Korea); Wonpyo Kwon (Pohang University of Science and Technology, Korea); Wonbin Hong (Pohang University of Science and Technology (POSTECH), Korea)
This paper describes an optically transparent one dimensional (1-D) electromagnetic bandgap (EBG) antenna using sub-skin depth thin-film alloy for millimeter-wave frequencies. The measured attenuation factor of RF testing devices fabricated with sub-skin depth thin-film alloy is characterized to be less than 0.3 dB/mm at 30 GHz. To ensure high directivity in the end-fire direction, 1-D EBG unit cells are implemented on the top surface of the thin-film alloy.

11:50 ***Measurements of Window Penetration Loss and Building Entry Loss from 3.5 to 24 GHz***

Young Chul Lee (Mokpo National Maritime University, Korea); Soon-Soo Oh and Hwa Choon Lee (Chosun University, Korea); Chul Woo Byeon (Wonkwang University, Korea); Sung-Won Park, Il-Yong Lee, Jong-Hyuk Lim and Jong-Il Lee (National Radio Research Agency (RRA), Korea); ByungLok Cho (Sunchon National University, Korea)
This paper presents the results of a window penetration loss (WinPL) and building entry loss (BEL) of a traditional office building from 3.5-24 GHz. In order to investigate the factor that most affected BEL frequency-dependence, the WinPL of an on-site window was measured and analyzed using a penetration loss simulation of the double-glazed glass. Both experiments show an oscillatory dependence of the loss on frequency. A cumulative distribution function (CDF) generated from the BEL data at different frequencies was analyzed in terms of depth within the building. As the results, as a receiver (Rx) moved deep inside the building, the BEL increased. For 50 % values extracted from the CDF data, the frequency characteristics of all locations were similar to those of the WPL. As with WinPL, the BEL is high at 6 and 18 GHz, and low at 3.5, 10, and 24 GHz. For the traditional office buildings with double-glazed external windows, the BEL frequency-dependence is directly affected by the WPLs of the windows

Thursday, April 4 8:40 - 10:20

MT_M01 RF mat char: MT_M01 Techniques and tools for RF material characterisation

TOP

Methods & Tools / Regular Session / Measurements

Room: Oral Sessions: S4-B - Lublin

Chairs: Filippo Costa (University of Pisa, Italy), Bernd Gabler (German Aerospace Center (DLR), Germany)

8:40 ***Detection of Surface Cracks in Metallic Materials Using an Enhanced Symmetrical Split Ring Resonator***

Rammah A. Alahnomi (Universiti Teknikal Malaysia Melaka (UTeM), Malaysia); Zahriladha Zakaria, Noor Azwan Shairi, Zulkalnain Mohd Yussof and Amyrul Azuan Mohd Bahar (Universiti Teknikal Malaysia Melaka, Malaysia); Ammar Alhegazi (University Technical Malaysia Melaka (UTeM), Malaysia)
An enhanced sensor based on symmetrical split ring resonator (SSRR) functioning at microwave frequencies has been proposed for detecting and characterizing the cracked surface of the metal materials. The enhanced SSRR sensor is modelled using a High Frequency Structure Simulator (HFSS) and the reflection S11 is performed for testing the aluminum metal with crack and without crack at the frequency range of 100 MHz to 3GHz. Variation of crack width and depth has been investigated and the most obvious finding emerged from this study is that the ability of detecting a minimum of sub-millimetre crack width and depth which is a round 10 μm width or depth where the minimum shift of reflected frequency is recorded at 6 MHz and 3 MHz for crack width and depth respectively. The enhanced SSRR provides high capability of detecting small crack defection by utilizing the interaction between coupled gap resonators and it is useful for various applications such as aircraft fuselages, nuclear power plant steam generator tubing, and steel bridges and for others that can be compromised by metal fatigue.

9:00 ***Effect of SEY in Low Energy Region on Multipactor Threshold of the High Frequency Microwave Components***

Guanghui Miao (China Academy of Space Technology (Xi'an) & National Key Laboratory of Science and Technology on Space Microwave, P.R. China); Wanzhao Cui (China Academy of Space Technology Xi'an, P.R. China)
The secondary electron emission yield (SEY) in the low energy region (0-50eV) has always been an important parameter that restricting the performance of electron accelerators, high power microwave sources and space microwave devices. In this paper, a new method of approximate measurement of secondary electron emission yield with "double-meter method" at incident energy less than 50 eV is introduced based on the commonly used measurement methods and the inherent conditions and structural characteristics of existing equipment. According to the experimental results and the data published in the international research, the accuracy of the measurement theory and experimental operation is verified, and a set of SEY curves of common metals in low energy region are obtained. Finally, the impedance transformer is designed to simulate the multipactor and compare with the measured results, which is used to study the influence of low-energy secondary electron emission coefficient on the threshold of multipactor. It is found that the SEY curve containing the low-energy region greatly improves the simulation accuracy of multipactor. The error between the simulation value and the measured value is less than 2%.

9:20 ***Rigorous Equivalent Circuit of a Patch Loaded Coaxial Permittivity Sensors***

Harshitha Thippur Shivamurthy, Marco Spirito and Andrea Neto (Delft University of Technology, The Netherlands)
The design of a patch loaded coaxial sensor in planar technology can be a challenging task. More so if the material under test (MUT) is very dense and the frequency of operation is high. In this paper, the coaxial loaded sensor is characterized using an equivalent circuit that provides the complete picture (qualitative and quantitative) of the fields. The entire patch with the ground plane is modelled as a parallel plate waveguide with a frequency dependent transformer used to describe the coupling from the coaxial cable to the parallel plate waveguide. The impact of the MUT is accurately included in the evaluation of the end point load of the transmission line. This load is evaluated resorting to an in-house tool based on a dedicated Method of Moments (MoM) procedure. The transmission line model is validated with the equivalent results obtained by full wave simulations performed via a commercial tool based on Finite Differences in time domain

9:40 ***Depolarizing Chipless RFID for Non-Contact Material Heath Testing***

Filippo Costa (University of Pisa, Italy); Antonio Lazaro (URV, Spain); Simone Genovesi (University of Pisa, Italy); Ramon Villarino and David Girbau (Universitat Rovira i Virgili, Spain)
Depolarizing Chipless RFID for Non-Contact Material Heath Testing

10:00 ***Nuclear Magnetic Resonance Volumetric Antenna***

Achraf Waguaf (ENSEIRB MATMECA, France); Ludivine Fadel, Valerie Vigneras and François Demontoux (Universite de Bordeaux, France); Abdoulaye Fall (Université Paris-Est, France); Hakim Takhedmit (Paris-Est Marne-la-Vallée University, France); Marjorie Grzeskowiak (ISAE Supaero, France)
The paper proposes NMR antennas. The idea is to realize antenna dedicated to the study of unsaturated granular material. The aim is to design volumetric antenna whose small size allows increasing the measurement sensibility. The objectives are twofold: enhance the H-field homogeneity and the Signal-to-Noise Ratio.

Thursday, April 4 8:40 - 12:30

CS11 GNSS Ant: CS11 GNSS antennas and antenna systems

TOP

Localization & Connected Objects / Convened Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Loic Bernard (ISL, France), Slobodan Jović (Defence R&D Canada, Canada)

8:40 ***Design of GNSS Antenna Using Polarizer***

Mohamad Mantash and Tayeb A. Denidni (INRS-EMT, Canada)
In this paper, a novel wideband circularly polarized global navigation satellite system (GNSS) antenna, operating in the frequency band 1 - 1.6 GHz is presented. An artificial magnetic conductor (AMC) reflector is employed for directing the radiation of the antenna only in the positive z-plane. The proposed antenna uses a simple single layer 2D frequency selective surface (FSS) polarizer to convert the linearly polarized wave radiated by the antenna into a circularly polarized wave. This polarizer consists of an array of 11 x 11 "T" shaped unit-cells that works in the 1 - 1.7 GHz frequency band at normal and oblique incidence. To demonstrate the validity of the antenna, simulation results by placing the "T" shaped polarizer in the broadside direction of the antenna have been

shown. An axial ratio (AR) smaller than 3 dB is obtained in the desired GNSS frequency band from 1 to 1.6 GHz with gain enhancement, demonstrating the effectiveness of the polarizer.

9:00 ***A Novel Circularly Polarized GNSS Antenna with Broadband Feed Network***

Tao Zhou and Qing-Xin Chu (South China University of Technology, P.R. China)

A novel broadband GNSS antenna is presented. A new type broadband feed network, combined with four large fan-shaped copper sheets which corners are cut off is used to realize the broad bandwidth.

9:20 ***Using a Bio-Inspired Algorithm for Efficient Angle-of-Arrival Estimation of GNSS Jammers***

Elizabeth Lloyd and Robert J Watson (University of Bath, United Kingdom (Great Britain))

This paper presents a novel use of the Invasive Weed Optimisation algorithm: to quickly locate GPS jammers using a low power, low cost, small system. GPS jammers are often used by criminals and as such, there is a requirement from law enforcement agencies for such a system. In this paper a small, two element antenna array is used with a low power, digitally controlled beamformer. An Invasive Weed Optimisation algorithm controls the beamformer to find the Angle of Arrival of a GPS jamming signal from a real jammer. The system is able to determine the angle of arrival of the jammer in less than half the time required for a full exhaustive sweep.

9:40 ***Circularly-Polarized Metasurface Antenna in Cavity for GNSS Applications***

Laura Garcia-Gamez (IETR Institute of Electronics and Telecomunications of Rennes & ISL French-German Research Institute of Saint-Louis, France); Loic Bernard (ISL, France); Ronan Sauleau, Sylvain Collardey and Kourosh Mahdjoubi (University of Rennes 1, France); Pouliguen Philippe (DGA, France); Patrick Potier ((DGA), France)

An innovative circularly-polarized (CP) compact antenna is presented here, with the aim to cover three GNSS systems simultaneously, namely Galileo E1, GLONASS G1 and GPS L1, corresponding to a minimum impedance bandwidth of 60 MHz. The proposed design consists of a metasurface-inspired antenna, embedded in a metallic cavity, with a total aperture size of 0.21 λ0 × 0.21 λ0 centered at the frequency of 1578 MHz. The simulation results demonstrate that it is possible to reach a much wider bandwidth (180 MHz). Experimental results successfully validate the proposed design.

10:00 ***A Miniaturized GNSS Controlled Reception Pattern Antenna Array with AMC Virtual Ground Plane***

Andrej Konforta, Steven Horn, Thomas Bertuch and Peter Knott (Fraunhofer FHR, Germany)

In this contribution, the feasibility of a size-reduced Controlled Reception Pattern Antenna (CRPA) that incorporates seven radiators and an Artificial Magnetic Conductor (AMC) is investigated. The presented design is tailored for satellite navigation signal reception within the L1-Band. It allows for spatial-selective noise suppression to achieve an increased robustness against jamming equipment while maintaining small outer dimensions. The design of a miniaturized CRPA as well as measurement results of the implementation are presented.

10:20 Coffee Break

10:50 ***28GHz Dual Polarized Beam Steering Antenna with Substrate Integrated Frequency Selective Structure***

Halim Boutayeb (Huawei Technologies, Canada); Wen Tong (Huawei Technologies Canada Co., Ltd., Canada); Fayez Hyjazie (Huawei Technologies Co. Ltd., Canada)

we propose a new type of mm wave beam steering antennas that permits larger steering angular range and almost no gain dispersion versus steering angle. Indeed, the limited angular range and the gain decrease when the steering angle increases are the main drawbacks of conventional planar phased arrays. The proposed design method starts with a substrate integrated waveguide which has a switchable frequency selective structure. The next design steps consist on a dual polarized conformal arrays, the feeding port structure of a power divider in a radial waveguide, the transitions to the radiating elements, the substrate integrated circular frequency selective structure and finally the full antenna. Based on this design methodology, a dual polarized beam steering antenna operating at 28 GHz is presented.

11:10 ***GNSS Reflectometry Systems for Soil Permittivity Determination***

Patrizia Savi, Silvano Bertoldo and Albert Milani (Politecnico di Torino, Italy)

Global Navigation Satellite System Reflectometry (GNSS-R) can be successfully used to obtain information about the composition or the properties of ground surfaces, by analyzing GPS signals reflected by the ground. The received power of these signals is proportional to the moduli of the perpendicular and parallel polarization Fresnel coefficients, which in turn depend on the incidence angle and the ground's permittivity, a parameter related to the ground surface's physical properties. The goal is then to obtain the value of permittivity from the known value of the angle of incidence and the values of the Fresnel reflection coefficients, as measured by an automatic GNSS-R system. In general, the permittivity is a complex number: in some cases (e.g. for non-dispersive soils), its imaginary part can be neglected, and the permittivity can be assumed to be a real number. In this case, it is possible to solve the Fresnel reflection coefficients explicitly in terms of the permittivity. The corresponding solution formulas can then be used also to verify the validity of other empirical methods of determination of the permittivity. In this work, we present these formulas, and present a set of their verification, against know values of the permittivity obtained by independent measurements.

11:30 ***Radiation Characteristics of Differentially-Fed Dual Circularly Polarized GNSS Antenna***

Markus Berg (University of Oulu & Excellant LTd., Finland); Jiangcheng Chen and Aarno Pärssinen (University of Oulu, Finland)

This paper discusses the method to create a dual circular polarized antenna for GNSS applications. First time, the differentially-driven circular patch is demonstrated to create a feasible cross-polarization discrimination (XPD) for phase accurate antenna structure. Traditional choke rings are applied to control the radiation pattern characteristics. A separate feed network is used to obtain simultaneous left and right hand circular polarizations for the corresponding coaxial connectors of the antenna. The operation of the feed network is described by using a block diagram. Resulting antenna radiation parameters include max. gain of 6.2 dB, axial ratio <3 dB over the upper hemisphere for the frequency range 1.55-1.61 GHz. The simulated antenna response for right hand polarized plane wave excitation demonstrate 27-29 dB isolation between the left and right hand antenna ports.

11:50 ***A Dualband Smart Antenna Set for Precise GNSS Applications in Car***

Sebastian Matthie (Universität der Bundeswehr München, Germany); Stefan Lindenmeier (Universität der Bundeswehr, Germany)

A micro-diversity-set of two dual-band antenna radiators for high gain reception of the most important GNSS services like GPS, GLONASS and BeiDou in L1 and L2 band is presented. It allows high precision navigation by offering of three decoupled antenna signals which can be constructively combined by a diversity system. The smart construction allows its placing underneath tiny housings of typical automotive applications. With a lean design based on two punched bent metal sheets the antenna set enables an easy realization. Simulated and measured results of the laboratory and anechoic chamber show its high capability of reception of RHCP waves and high suppression of unwanted reflected LHCP waves for GNSS reception.

12:10 ***Annular Dielectric Resonator-Based Antenna for Multifrequency GNSS Applications Details on the Engineered Surface Inset***

Slobodan Jović (Defence R&D Canada, Canada); Michel Clénet (Defence Research and Development Canada, Canada); Yahia Antar (Royal Military College of Canada, Canada)

This paper focuses on the design of a 'decoupling network' used for the concept of a novel wideband compact antenna for multi-frequency Global Navigation Satellite Systems (GNSS) application and possibly L-band satellite communications, covering 1.15 to 1.62 GHz. The antenna is based on ring dielectric resonator (DR) with a conformal cylindrical engineered surface, the so-called 'decoupling network', inserted on its inner diameter. The antenna is excited with 4 ports fed with a 90o phase difference to achieve good circular polarization over a wide beamwidth. The engineered surface plays the role of a decoupling network for the feeds, and contributes to the antenna gain and impedance bandwidth enhancement. The engineered surface has been extensively investigated to better understand its impact on the antenna radiation and matching. Some results of this study are provided in this paper.

Thursday, April 4 8:40 - 10:20

R_A04 Radar ant: R_A04 Radar antennas

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Radars / Regular Session / Antennas

Room: Oral Sessions: S4-D - Bytom

Chairs: Muhammad Ali Babar Abbasi (Queen's University Belfast & The Institute of Electronics, Communications and Information Technology (ECIT), United Kingdom (Great Britain)), Shengjian Jammy Chen (The University of Adelaide, Australia)

8:40 ***Circular Array Retrodirective Action Using a Rotman Lens Beamformer***

Anil Chepala (Queen's University of Belfast, United Kingdom (Great Britain)); Vincent Fusco (Queen's University Belfast, United Kingdom (Great Britain)); Muhammad Ali Babar Abbasi (Queen's University Belfast & The Institute of Electronics, Communications and Information Technology (ECIT), United Kingdom (Great Britain))

We present the first use of a circular array for retrodirection covering full 360°. In particular, we discuss the attributes of the circular array when combined with Rotman beam forming. For reference the characteristics of the circular array when performing retrodirective action using local per element conjugation is also demonstrated. Simulated and measurement results at X-band are presented. The retrodirective circular array provides the advantage of 360° coverage when compared to other retrodirectors based on uniform linear arrays, as these typically allow only up to ±40° sector coverage.

9:00 ***Imaging System for Automotive Radome Characterization***

Santi Buitrago (CommSenseLab, Universitat Politècnica de Catalunya, Spain); Sebastian Blanch Boris and Jordi Romeu (Universitat Politècnica de Catalunya, Spain)

In this paper, a setup to obtain an image of the attenuation and the reflectivity of an automotive radome in the 77 GHz band is presented. The characterization of the reflectivity is becoming an important issue to be considered in an automotive radome design because the important effects it can produce in the radar sensor performance such as a false detection of a target or even a blindness of the radar sensor. In addition, the characterization of the attenuation is also important because the reduction in safety due to a possible non-detection of a target. For that reason, a setup to obtain an image of the attenuation and the reflectivity of a radome at the same time is presented. This system can be used to test prototypes in the design process or in the verification of manufactures samples.

9:20 ***Selective Metallization of Graphene-based Polymers for Volumetric 3D-printed Antennas***

Dmitry Filonov and Pavel Ginzburg (Tel Aviv University, Israel)

Modern 3D-printing techniques allow efficient exploration of the third space dimension, providing advantages over conventional planar architectures. In particular, volumetric electromagnetic antennas can outperform their planar counterparts. Here a new approach to fabrication of electromagnetic devices is developed and applied to antennas, implemented on B-spline surfaces. The antenna skeleton and the support were simultaneously printed with different polymer materials - PLA mixed with graphene flakes and pure PLA, respectfully. Weakly DC-conductive graphene PLA-based skeleton was post-processed and high quality conductive layer was selectively electrochemically deposited on it. The antenna devices were found to demonstrate radiation performance, similar to that achievable with conventional fabrication approaches. However, additive manufacturing of RF antennas provides superior capabilities of constructing tailor-made devices with properties, pre-defined by non-standardized end users.

9:40 ***A Two-Port Microstrip Sensor Antenna for Permitivitty and Loss Tangent Measurements***

Mohammad Mahdi Honari, Rashid Mirzavand, Hossein Saghlatoon and Pedram Mousavi (University of Alberta, Canada)

A two-port microstrip sensor antenna is presented for characterizing different materials. The proposed sensor antenna can estimate both permittivity and loss tangent of a sample under test (SUT). The permittivity of material has huge impact on the antenna resonance, while its loss tangent affects power transmitted to the second port. Therefore, by finding out the antenna resonance and the level of transmission response, one can characterize the materials. The results show that the antenna radiation pattern is not deteriorated for samples with different permittivities and loss tangents.

10:00 ***UWB Horn Antenna Array Fabricated in Additive Manufacturing Technology***

Christian Canestri (Elettronica S.p.A., Italy); Francesco Scattone (Microwave Vision Group (MVG), Italy); Pietro Bia, Ivan Russo and Domenico Gaetano (Elettronica S.p.A., Italy); Antonio Manna (Elettronica SpA, Italy)

This work investigates the capabilities of Additive Manufacturing (AM) technology applied to the fabrication of an ultra-wideband (UWB) horn antenna array that works in the C frequency band. A comparison between standard Electrical Discharge Machining (EDM) or milling processes and AM is presented considering several parameters such as cost, feasibility, specific weight and process accuracy. The antenna array consists in 3x16 horn antennas having a lattice with alternated shift on the elevation plane to reduce the mutual coupling. The measured performances of the AM array are compared with the CST simulations of the full-aluminum array. The results demonstrate that, besides the technological advantages, the presented AM process provides electromagnetic equivalence with respect to conventional full metallic arrays.

H_A01 MIMO Smart: H_A01 MIMO, Diversity, Smart Antennas & Signal Processing

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High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Ioan E. Lager (Delft University of Technology, The Netherlands), Yevhen Yashchyshyn (Warsaw University of Technology, Poland)

8:40 ***Single RF Chain MIMO Receiver Using Beam-Steering Time Modulated Antenna Array***

Grzegorz Bogdan, Konrad Godziszewski, Yevhen Yashchyshyn and Sebastian Kozłowski (Warsaw University of Technology, Poland)

Typically, MIMO systems require multiple antennas and multiple radio frequency (RF) chains in order to obtain uncorrelated spatial channels. This leads to cumbersome designs which are expensive to fabricate and consume a lot of energy. This paper shows a MIMO receiver with only one RF chain, which can significantly reduce cost of a MIMO system. Proposed single-RF MIMO receiver is based on a time modulated antenna array. Diverse channels were obtained by periodical ON/OFF switching. Beam-steering was used to further improve the performance of a MIMO system by focusing the main beam of the receiving antenna toward some desired direction in space.

9:00 ***Dual-Band MIMO Antenna System for 5G Mobile Terminals***

Zhouyou Ren, Anping Zhao and Shengjie Wu (Shenzhen Sunway Communication Co., Ltd, P.R. China)

A dual-band eight-antenna system for multiple-input multiple-out (MIMO) applications in future 5G mobile terminals is presented in this paper. The proposed antenna system consists of eight antenna elements which are placed along two long edges of the mobile terminal. Good antenna total efficiency is obtained for both the low band and high band, while the isolation is better than 15dB between each port. Envelope correlation coefficient (ECC) and channel capacity (CC) are also used to evaluate the MIMO performances of the proposed MIMO antenna system. Antenna prototype is fabricated and measured; and quite good agreement between simulation and measurement is obtained.

9:20 ***28 GHz Multi-Beam Antenna Array Based on Wideband High-dimension 16X16 Butler Matrix***

Xiaozhou Wang (Technical University of Dresden, Germany); Martin Laabs and Dirk Plettemeier (Dresden University of Technology, Germany); Keishi Kosaka (NEC, Japan); Yasuhiko Matsunaga (NEC Corporation, Japan)

28 GHz multi-beam array system employing a wideband high-dimension 16x16 Butler matrix as the Beamforming Network (BFN) is presented for wireless communication with high data rate. The complexity of high-dimension 16x16 Butler matrix is significantly reduced by utilizing a simple three-layer Microstripline (ML) structure to ease the design and fabrication. The proposed multi-beam array system based on wideband components can operate in a frequency range of 25 GHz to 30 GHz with the insertion loss of 4.8 dB at 28 GHz. 16 orthogonal beams with enhanced directional characteristics, i.e. 16 dBi main beam gain and 7 degree Half Power Beam Width (HPBW) covering a spatial angle range of ±68 degree are experimentally achieved. In addition, the measured radiation patterns at the different feeding frequencies (27 GHz, 28 GHz and 29 GHz) are compared to evaluate the true-time-delay effect in Butler matrix.

9:40 ***Performance Evaluation of Mobile Hotspot Network Prototype System***

Sung Woo Choi (ETRI, Korea); Junhyeong Kim (ETRI & KAIST, Korea); Ilgyu Kim (ETRI of KOREA, Korea)

This paper presents performance evaluation of mobile hotspot network (MHN) prototype system. The MHN was proposed to provide passenger's Internet access in railways. The system architecture and features of physical layer specification are provided. The evaluation is realized using hardware prototypes in roads for low speeds and using computer simulations for high speeds. The simulation results show the MHN-E system of 1GHz bandwidth can provides about 3.6 Gbps at 500 km/h. Furthermore, we conducts experiments to specify the effect of cross interference of polarized antennas. The results show the presence of that factor will affect the quality of the signals and degrade the data throughput.

10:00 ***Pulsed EM Field Radio: The Low-Power, Ultra-fast Bridge to Ubiquitous Fiber Networks***

Ioan E. Lager (Delft University of Technology, The Netherlands); Domenico Zito (University College Cork & Tyndall National Institute, Ireland)

The suitability of pulsed electromagnetic (EM) field radio as a low-power, ultra-fast instrument for bridging the gap between mobile terminals and ubiquitously deployed fiber-optic networks is investigated. An in-depth study of the present trends in fifth generation (5G) mobile communications strategies is carried out, by highlighting the crucial role of Terahertz (THz) and 'low-GHz' ultra-wideband (UWB) radio implementations. Upon recognising the low-power capabilities of 'low-GHz' UWB solutions, the contribution zooms in on the pulsed EM field transfer and on the features of a monocycle pulse generator that is deemed conditional for future physical realisations of the concept.

F_A11 Future ant 2: F_A11 Future antennas 2

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Future Applications / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Manuel Arrebola (Universidad de Oviedo, Spain), Mario Orefice (Politecnico di Torino, Italy)

8:40 ***An Efficient Trust-Region Algorithm for Wideband Antenna Optimization***

Slawomir Koziel and Anna Pietrenko-Dabrowska (Gdansk University of Technology, Poland)

Simulation-driven design closure is a necessary step in the design of modern antenna structures. It is typically realized using parameter sweeping. Application of numerical optimization routines brings better results but it may be computationally expensive due to numerous electromagnetic (EM) analyses involved in the process. Reduction of the optimization cost can be achieved using various methods, e.g., surrogate-assisted techniques, reduction of the problem dimensionality, etc. Yet, either the main task or its sub-problems (e.g., surrogate model optimization) have to be solved directly. Here, an improved trust-region algorithm working with numerical derivatives is proposed that permits considerable reduction of the number of EM simulations in the optimization process. Our approach utilizes a smart management of antenna response Jacobian updates derived from relative changes of geometry parameters during subsequent iterations. Our methodology is demonstrated using a benchmark set of wideband antennas. Comparison with a conventional trust-region routine is provided along with a comprehensive analysis of algorithm performance

involving multiple starting points. The impact of control parameters is also investigated. The average computational savings across the benchmark set are around 50 percent with acceptable degradation of the solution quality.

9:00 ***Design of a Reconfigurable Array of Monopoles for the Netherlands China Low-frequency Explorer***

Michel Arts (ASTRON, the Netherlands Institute for Radio Astronomy, The Netherlands); David S Prinsloo (ASTRON & Netherlands Institute for Radio Astronomy, The Netherlands); Mark Ruiter and Albert Jan Boonstra (ASTRON, The Netherlands)

The Netherlands China Low-frequency Explorer (NCLE) is a scientific payload hosted on the Chang'e 4 relay satellite, part of the Chinese Lunar Exploration Program. It is a pathfinder for a low frequency Moon-based interferometer for frequencies between 80 kHz and 80 MHz. The antenna of NCLE consists of three monopoles with a length of 5 meter. Each pair of monopoles can be configured as a dipole. This will be done in the digital domain. In this paper the design considerations taken into account during the development of the NCLE antenna system will be presented. Furthermore the sensitivity and polarimetric performance achieved over the operating frequency band of the NCLE antenna system are shown and design considerations for future space-based low-frequency radio telescopes will be discussed.

9:20 ***Comparison Between Analytic Derivative and the Technique of Differential Contributions in Reflectarray Phase-Only Synthesis***

Daniel R. Prado (Heriot Watt University & School of Engineering & Physical Sciences, United Kingdom (Great Britain)); Manuel Arrebola and Marcos R. Pino (Universidad de Oviedo, Spain); George Goussetis (Heriot-Watt University, United Kingdom (Great Britain))

Many algorithms for the optimization of array antennas need the calculation of a gradient to minimize a cost function. Usually, the best approach is to compute analytically the derivatives, since that way computations are faster. However, sometimes the derivatives are cumbersome to obtain or they cannot be calculated, such as when directly optimizing the layout in reflectarrays for cross-polarization improvement. In those cases, derivatives are evaluated using numerical techniques such as finite differences. In this work, we present the numerical technique of differential contributions (DFC) to accelerate gradient based algorithms when the derivatives are calculated with finite differences, achieving a complexity time scaling of the same order as the analytical derivatives. The technique is applied to a far field phase-only synthesis for reflectarray antennas using the generalized Intersection Approach, and it is compared with the analytic derivatives and the use of finite differences with the FFT. The DFC technique shows superior performance in all cases, even than the analytic derivative.

9:40 ***The Effect of Non-Uniform Conductivity on Radiation Characteristics of a Monopole Plasma Antenna***

Mahsa Valipour, Fatemeh Sadeghikia and Ali K. Horestani (Aerospace Research Institute, Iran); Hajar Ja'afar (Universiti Teknologi MARA, Malaysia)

This study examines the effects of the tapered conductivity of plasma in a surface-wave excited plasma antenna on its radiation characteristics including resonant frequency, bandwidth, gain and input impedance. It is observed that if the plasma density in a uniform plasma column is considerably smaller than the equivalent plasma density of copper the resonant length of the plasma antenna is smaller than its equivalent metallic antenna. The results also indicate that a tapered conductivity distribution along the column (which can be formed in a surface-wave excited plasma) decreases the resonant length of the antenna up to around 20 %. It is shown that a tapered conductivity plasma antenna has also a slightly wider bandwidth. However, these advantages are achieved at the cost of lower of lower radiation gain, which is due to higher loss in the plasma column.

10:00 ***Multi-Beam Frequency Tunable Antenna Based on Plasma-Nested Helix***

Fatemeh Sadeghikia, Mohammad reza Dorbin, Ali K. Horestani and Mahmoud Talafi Noghani (Aerospace Research Institute, Iran); Hajar Ja'afar (Universiti Teknologi MARA, Malaysia)

A frequency tunable antenna supporting multiple beams based on plasma technology is presented in this letter. Key components of the proposed antenna are an axial mode helical antenna and a nested plasma column antenna inside the helix. The antenna has the potential to operate in the frequency range of VHF (200-400 MHz), with a broadside radiation pattern and L band (900-1500 MHz) with an end fire radiation pattern. The proposed structure has the ability to restrict its performance in the only L band frequency range. The radiation characteristics are analyzed and investigated using the finite integral technique.

Thursday, April 4 8:40 - 12:30

CS33 Horizon 2020 (EMERALD): CS33 Horizon 2020 research and innovation session (EMERALD): ElectroMagnetic imaging for a novel genERation of medicAL Devices

TOP

Biomedical / Convened Session / Propagation

Room: Oral Sessions: A2- Ustka

Chairs: Lorenzo Crocco (CNR - National Research Council of Italy, Italy), Panagiotis Kosmas (King's College London, United Kingdom (Great Britain))

8:40 ***Advancing Microwave-Based Imaging Techniques for Medical Applications in the Wake of the 5G Revolution***

Jean-Charles Bolomey (Supelec Université de Paris Sud XI, France)

This paper is to serve as introduction to a convened session dedicated to the ElectroMagnetic imaging for a novel genERation of medicAL Devices project (EMERALD). It consists in a brief review of the current status of microwave-based imaging techniques and aims to identify their possible future evolution scenarios within the frame of the expected development of 5G and other IoT wireless devices.

9:00 ***Phantoms for a Novel Generation of Medical Microwave Imaging Devices***

Soroush Abedi (Group of Electrical Engineering - Paris, France); Nadine Joachimowicz and Olivier Meyer (Group of Electrical Engineering - Paris / CentraleSupelec, France); Dominique Picard (EDF R&D, France); Hélène Roussel (Sorbonne Université, L2E)

This paper shows that the manufacturing process presented in our previous work which was used for building time-stable and remotely reproducible breast and head phantoms, opens up new avenues for mimicking any type of biological tissues in the frequency range of [500 MHz - 3 GHz]. Moreover, the numerical version of the phantom (STL format file) enables to test its conformity, as well as experimental configurations. The study is placed in the framework of the European project EMERALD.

9:20 ***Development of an EM Device for Cerebrovascular Diseases Imaging and Hardware Acceleration for Imaging Algorithms Within the EMERALD Network***

David O. Rodriguez Duarte, Mohammad Amir Mansoori, Jorge Alberto Tobon Vasquez, Giovanna Turvani, Mario Roberto Casu and Francesca Vipiana (Politecnico di Torino, Italy)

This paper is presenting the first months of research activities within the Marie Skłodowska-Curie Innovative Training Network "EMERALD" developed by the Politecnico di Torino group. Our research work is related to the development of an electromagnetic device for cerebrovascular diseases imaging and to the hardware acceleration of the implemented imaging algorithms via field-programmable gate arrays or application-specific integrated circuits coupled with regular multicore central processing units and even graphics processing units.

9:40 ***Early-stage Dielectric Characterisation of Renal Cell Carcinoma for Positive Surgical Margin Detection***

Alessandra La Gioia (National University of Ireland Galway, Ireland); Muhammad Adnan Elahi (National University of Ireland, Galway, Ireland); Anna Bottiglieri (Translational Medical Device Lab & National University of Ireland, Galway, Ireland); Niko Ištuk (National University of Ireland, Galway, Ireland); Catherine Dowling and Frank D'Arcy (University Hospital Galway, Ireland); Martin O'Halloran (National University of Ireland, Galway, Ireland); Emily Porter (National University of Ireland Galway & Translational Medical Device Lab, Ireland)

Partial nephrectomy is preferred to total nephrectomy for clinically localised renal cell carcinoma. Currently, the risk of positive margins during partial nephrectomy is minimised with the use of intraoperative ultrasound. In this study, dielectric spectroscopy is proposed for the detection of positive margins. Specifically, the feasibility of using an open-ended coaxial probe operating at microwave frequencies is evaluated for in vivo differentiation between positive and negative surgical margins. Due to the lack of dielectric properties of renal cancerous tissue in the literature, early stage ex vivo dielectric measurements were conducted on five human renal samples immediately after excision. A wide range of dielectric measurement results were obtained due to the heterogeneity of renal samples and the different longitudinal location of the cancerous tissue across the samples. This outcome suggests the need to refine the protocol for dielectric characterisation of renal cell carcinoma and highlights the limitations of a coaxial probe at detecting renal tumour margins.

10:00 ***Advances Towards the Development of a Brain Microwave Imaging Scanner***

Syed Ahsan (King's College London, United Kingdom (Great Britain)); Maria Koutsoupidou (King's College London, UK); Eleonora Razzicchia (King's College, United Kingdom (Great Britain)); Ioannis Sotiriou and Panagiotis Kosmas (King's College London, United Kingdom (Great Britain))

This paper presents some hardware advances towards a microwave system for brain imaging. In particular, we present a new antenna array design for efficient propagation of microwave signals in the head, as well as a metamaterial structure designed for transmission enhancement through impedance matching. The presented system is modelled in CST Microwave Studio, using a specific anthropomorphic mannequin (SAM) head model to analyse performance. Simulations results suggest that our designs can be useful in designing a microwave scanner for brain imaging applications such as stroke detection and monitoring.

10:20 Coffee Break

10:50 ***Survey and Classification of Antennas for Medical Applications***

Tushar Singh Singh (University of Belgrade & WIPL-D, Serbia); Marija Nikolic Stevanovic (School of Eletrical Engineering, University of Belgrade, Serbia); Branko Kolundzija (University of Belgrade, Serbia)

In this paper we give a detailed survey of various antenna types used in microwave medical applications. This is the first step towards a development of a thorough numerical library containing various components used in microwave medical systems such as antennas, phantoms, matching media, etc. The goal of this effort is to enable researchers in this field, to efficiently and easily test their algorithms and/or hardware using standardized components. In addition, such a library would encourage considering the whole system instead of partial approach in which e.g., developing imaging algorithms ignored the physical sensors etc. Here, we consider various antenna designs that have emerged in the last twenty years. In particular, we discuss the chronological evolution of antennas for hyperthermia, biotelemetry and microwave imaging. We also classify antennas with respect to utilized frequency band, such as Medical Implant Communication Service (MICS), industrial, scientific and medical (ISM) radio bands, and ultra wide-band (UWB).

11:10 ***Innovative Imaging Tools and Devices for Clinical Monitoring Within the EMERALD Network***

Selçuk Özgür (CNR - National Research Council of Italy, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Marta Cavagnaro (Sapienza University of Rome, Italy); Paolo Rocca (University of Trento, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy)

The Marie Skłodowska-Curie Innovative Training Network "EMERALD" is a recently started project aimed at progressing the state of the art of microwave imaging devices for medical applications. In this framework, the goal of the project tasks based at CNR-IREA is twofold. First, ad-hoc imaging algorithms tailored to the prototype devices for clinical follow-up and image-guided treatment designed and realized within the network will be developed. Second, a microwave imaging device for monitoring and guiding microwave ablation treatments will be designed, realized and tested. This paper presents the initial research activities carried out by the CNR-IREA team within the EMERALD project.

11:30 ***S-parameter Calibration Procedure for Multiport Microwave Imaging Systems***

Manuel Kasper, Mykolas Ragulskis and Ferry Kienberger (Keysight Technologies, Austria)

Multitude of antennas are typically used in microwave imaging systems. Here we outline a simple and effective way for calibrating multiport imaging systems. By using only one additional component, an electronic calibration module (ECal), one port is calibrated and the calibration plane is thereby moved to the antenna connector. Assuming all antennas interact with the test phantom in the same way, the one-port calibration is transferred to all other antennas. For full calibration including the transmission path, the "unknown thru" technique is used. This calibration procedure is simple and can be performed more frequently, as it can be fully automated, and no RF components are perturbed.

11:50 ***Numerical Study of Differential Temperature Measurement in Human Muscle Tissue Using UWB Radar***

Ondrej Fiser, Jr. (Czech Technical University in Prague & Faculty of Biomedical Engineering, Czech Republic); Vojtech Hruby (Czech Technical University in Prague, Czech Republic); Sebastian Ley and Marko Helbig (Technische Universität Ilmenau, Germany); Jürgen Sachs (Ilmenau University of Technology, Germany); Jan Vrba (Czech Technical University, Czech Republic)

This paper deals with the numerical study of the differential temperature measurement by means of ultra-wide band (UWB) radar in the muscle tissue. The temperature range of interest corresponds to the hyperthermia tumor treatment (up to 45 °C). A 1D model based on Mason graphs and a simplified sandwich structure are introduced to observe the expected usable frequency band and differential signal dependence on the temperature change. Results show a linear dependence of the received radar signals on temperature change in the human muscle phantom. We numerically proved that it is possible to detect temperature changes inside the UWB signals backscattered from heated region.

12:10 ***Functional Microwave Imagining System Based on Cognitive Scanning for Brain Activities Monitoring: A Feasibility Study***

Mohammad Ojaroudi (University of Limoges/CNRS, France); Stéphane Bila (XLIM UMR 7252 Université de Limoges/CNRS, France); Philippe Leveque (CNRS & XLIM, France); Philippe Carré (University of Poitiers, France)

This paper presents a new concept of cognitive scanning using hybrid MIMO-phased array radar (HMPAR) for functional near-field imaging of brain activity in the framework of algorithm/architecture co-design. In the proposed paradigm, the communication challenges of cognitive scanning are concurrently searching, detecting and tracking the activated brain regions. The proposed system model is a HMPAR approach including MIMO array for target detection and MIMO-phased sub-array for tracking the detected targets in the allocated subarrays. In the current paper, we assess the feasibility of using a waveform and pattern (beam-forming and beam-steering) diversities for developing the proposed framework. In order to improve the resolution, contrast and accuracy of a characteristics target inside a biological phantom, some initial methods are employed for 1D time domain reflectometry and 2D visualization. Simulated results show that the proposed framework could be feasible for functional microwave imaging application.

Thursday, April 4 10:50 - 12:30

CS49 UWB Feed and PAF Radio Telescopes: CS49 Development of UWB Feed and PAF Technologies for Future Radio Telescopes

TOP

Space / Convened Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Dirk de Villiers (Stellenbosch University, South Africa), Jian Yang (Chalmers University of Technology, Sweden)

10:50 ***Design of Octave-bandwidth Phased Array Feed for Large Radio Telescope***

Jin Fan (National Astronomical Observatories, CAS, P.R. China); Jian Yang (Chalmers University of Technology, Sweden); Yihua Yan (National Astronomical Observatories, Chinese Academy of Sciences, P.R. China); Kai Zhu and Peng Jiang (National Astronomical Observatories, CAS, P.R. China); Hailin Cao (Chongqing University, P.R. China); Jun Ma (Xinjiang Astronomical Observatory, P.R. China); Bin Li (Shanghai Astronomical Observatory, P.R. China)

This paper presents design scenarios of Octave-bandwidth Phase Array Feed (PAF) based on a novel wideband dual polarized tightly-fed Bowtie antenna element. The PAF are optimized for the 4 - 8GHz band aiming to possible later integration in the SKA pathfinder PHAROS2. The proposed design can be a good candidate of PAF for the Five hundred meter Aperture Spherical Telescope (FAST) and Qi Tai Telescope (QTT) as well as other large radio telescopes.

11:10 ***Wideband Feed Performance Limits on Shaped and Unshaped Offset Gregorian Reflector Antennas***

Robert Lehmensiek (Cape Peninsula University of Technology, South Africa); Dirk de Villiers (Stellenbosch University, South Africa)

This paper investigates by means of a full parametric study the performance limits of both the classical conic section (unshaped) and shaped offset Gregorian reflector antenna systems with a theoretical ideal (and realistic) wideband feed at the focus. The ideal feed is optimized on each reflector system for maximum receiving sensitivity. It is shown that the difference in performance of shaped versus unshaped systems is significant, and that the optimum shaped reflector system exhibits a large and flat optimum region in the shaping parameter space.

11:30 ***Surrogate Based Optimization of Wideband Reflector Feed Antennas***

Dirk de Villiers and Fahmi Mokhupuki (Stellenbosch University, South Africa)

This paper presents a surrogate based optimization strategy for the rapid design of reflector antenna feeds. A multi-fidelity optimization scheme is employed, where the fast coarse model of the aperture efficiency is based on an interpolant of the Characteristic Basis Function Pattern (CBFP) coefficients. The training points of the interpolation model are selected by an expected improvement sequential design strategy, with the minimization goal function in this case, the negative aperture efficiency, penalized by the probability that the reflection coefficient magnitude exceeds a pre-defined limit. A Kriging model of the reflection coefficient magnitude is constructed from all available training data, which includes statistical information of the apparent model confidence over the full design space. An example of a quad-ridge flared horn design is presented, highlighting the efficiency of the suggested method.

11:50 ***Pattern Measurements of Cryogenically Cooled Ultra-Wideband Feed Horn***

Ken Smart (CSIRO Astronomy and Space Science, Australia); Alex Dunning (CSIRO, Australia); Stephanie Smith (CSIRO & Astronomy and Space Science, Australia); Nick Carter and Michael Bourne (CSIRO Astronomy and Space Science, Australia); Paul Doherty (CSIRO, Australia); Santiago Castillo (CSIRO Astronomy and Space Science, Australia); Bin Dong (National Astronomical Observatories, Chinese Academy of Sciences, P.R. China)

Thermal changes can have an effect not only on the dimensional stability of mechanical parts but also on their dielectric properties as well as the phase and amplitude of active components. An ultra-wide-bandwidth receiver has been developed for the Parkes Radio Telescope. Radiation patterns of the feed were measured at cryogenic temperatures in the CASS anechoic chamber at Marsfield. The internal features of the final design were adjusted to account for dimensional changes of the materials at cryogenic temperatures.

12:10 ***Sensitivity Simulation and Measurement of the SKA Band 1 Wideband Feed Package on MeerKAT***

Jonas Flygare (Chalmers University of Technology, Sweden); Adriaan Peens-Hough (SARAO, South Africa); Leif Helldner (Chalmers University of Technology, Sweden); Magnus Dahlgren (Onsala Space Observatory, Chalmers, Sweden); George Smit and Pieter Kotze (SARAO, South Africa); Ronny Wingden, Tobia Carozzi, Ulf Kylenfall, Lars Pettersson and Miroslav G. Pantaleev (Onsala Space Observatory, Chalmers University of Technology, Sweden)

Advances in wideband feed technology for radio telescopes enable high sensitivity observations over large bandwidths. The wideband quad-ridge flared horn (QRFH) feed package for Band 1 of the Square Kilometre Array (SKA) was optimized for high sensitivity. The 3:1 feed package covers 350-1050 MHz and is a complete room temperature system with low-noise amplifiers integrated inside the ridges of the horn. The QRFH is dual-linear polarized and designed with spline-defined profiles for the horn and ridge shape. Measured feed s-parameters show input reflection less than -11 dB across the band with good port isolation. In this paper we present the first measured sensitivity levels of the Band 1 feed package, which was tested on the SKA precursor reflector MeerKAT. We also present measured aperture efficiency and intrinsic cross-polarization (IXR). The measured results show good agreement with simulations.

MT_A08 Metamat: MT_A08 Metamaterials, metasurfaces and EBG for antennas

TOP

Methods & Tools / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Ioan E. Lager (Delft University of Technology, The Netherlands), Zvonimir Sipus (University of Zagreb, Croatia)

10:50 ***Frequency Reconfigurable Self-Oscillating Active Integrated Antenna Using Metamaterial Resonators and Slotted Ground Radiator***

Tzyh-Ghuang Ma, Yu Wei Chang, Huy Nam Chu and Wen-Jiao Liao (National Taiwan University of Science and Technology, Taiwan)

In this paper, the concept of a frequency reconfigurable self-oscillating active integrated antenna is proposed and experimentally validated by means of metamaterial resonators and slotted ground radiator. By controlling the switch on and off, the metamaterial resonator is reconfigured between a composite right-/left-handed (CRLH) structure and a Mu-negative (MNG) structure, with or without the shunt-to-ground inductance included. The oscillation property responds accordingly. The design concept and preliminary experimental results are introduced and discussed.

11:10 ***THz Thin Film Sensing with Labyrinth Metasurface Absorber***

Irati Jáuregui-López (Universidad Pública de Navarra, Spain); Pablo Rodríguez-Ulibarri (Asociación de Industria Navarra, Spain); Aitor Urrutia (Public University of Navarre, Spain); Sergei Kuznetsov (Novosibirsk State University, Russia); Miguel Beruete (Universidad Publica de Navarra, Spain)

In this work, a labyrinth metasurface sensor operating in the Terahertz (THz) band is presented. The strong electric field confinement leads to an excellent performance of this structure as thin film sensor. The sensing capability of the designed structure is numerically and experimentally measured. As the analyte thickness is increased, a frequency shift of the fundamental resonance is observed. Two different designs are studied both of them with excellent performance. An experimental average Figure of Merit (FOM) of 5093 (mm/RIU)-1 and 3111 (mm/RIU)-1 are obtained for both designs, improving the results obtained in the literature for structures fabricated with the same manufacturing techniques. Next, a numerical study of the behavior of the metasurface depending on the polarization characteristics is presented. The polarization angle of the incident E-field is varied between 0º and 90º showing a stable response in terms of the reflection coefficient. This aspect presents great advantages for thin film sensing, and could be extended to biological sensing in the future.

11:30 ***Experimental Verification of a Leaky-Wave Antenna Based on a Bianisotropic Huygens' Metasurface***

Elena Abdo-Sánchez (University of Málaga & E. T. S. I. Telecomunicación, Spain); Michael Chen (University of Toronto, Canada); Ariel Epstein (Technion - Israel Institute of Technology, Israel); George V. Eleftheriades (University of Toronto, Canada)

In this communication, the experimental verification of a leaky-wave antenna that uses a Huygens' metasurface to have a control on the radiation parameters is addressed. The antenna consists of a parallel-plate waveguide in which the top plate has been replaced by an omega-type bianisotropic Huygens' metasurface, in order to transform the guided mode into the desired leaky-mode with arbitrary choice of the leakage rates, pointing direction and waveguide height. The physical implementation of the metasurface is explained. Two design examples, radiating at broadside with different leakage factors, are implemented, manufactured and measured. Simulated and experimental results of the achieved directivity, scanning performance and radiation patterns are provided, experimentally corroborating the concept.

11:50 ***Analysis of Curved Metasurfaces with Spatially-Varying Impedance Distribution***

Zvonimir Sipus (University of Zagreb, Croatia); Dominik Barbaric (Ericsson Nikola Tesla dd, Croatia); Marko Bosiljevac (University of Zagreb, Croatia)

Metasurfaces have garnered significant attention in recent years since they act as electromagnetic devices that direct waves, manipulate the polarization of transmitted or reflected waves, or influence the spectrum properties of those waves. Till now most of the attention was focused on the development of planar metasurface structures, however, many demanding electromagnetic applications require the implementation of curved structures. We consider curved metasurfaces that are not homogeneous, i.e. metasurfaces that have spatially-varying distribution of surface sheet impedance. The proposed formulation also covers metasurfaces that do not encompass the entire canonical curved surface. The results are verified through several experimentally characterized cylindrical metasurface examples.

12:10 ***Volume Coil for MRI Based on Metasurface***

Anton Nikulin (PSL Research University, France); Benoit Larrat (CEA, Universit´e Paris Saclay, France); Julien de Rosny (Institut Langevin, ESPCI Paris, CNRS, France); Abdelwaheb Ourir (Institut Langevin ESPCI Paris CNRS, France)

Conventional birdcages are radiofrequency coils for magnetic resonance imaging (MRI). Analyzing these coils in terms of metasurface leads to engineering their properties as will and achieve original applications. To that end, we control the intrinsic impedance and the phase shift of each unit cell. As a demonstration, we use this concept to break the periodicity of the structure in order to provide a wide aperture allowing an easy access to the region of interest. We show that this coil, that we have called opencage, achieves good isolation between two driving ports and high homogeneity of the magnetic field. The results of measurements realized with phantom and in-vivo in MRI are presented. These results have confirmed the good performances predicted by our theoretical approach and the numerical calculations. This opencage coil could be used for many applications such as preclinical imaging of small animals or human head clinical imaging.

F_P06 Body Propag: F_P06 Body-area propagation

TOP

Future Applications / Regular Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Slawomir J. Ambroziak (Gdansk University of Technology, Poland), Kenan Turbic (IST - University of Lisbon & INESC-ID, Portugal)

10:50 ***Ultra Wideband in Vivo Channel Modelling with Respect to Ex Vivo Antenna Location***

Muhammad Ilyas and Oguz Bayat (Altinbas University, Turkey); Muhammad Ali Imran and Qammer H Abbasi (University of Glasgow, United Kingdom (Great Britain))

This article presents mathematical channel modeling for in-vivo communication in terms of the change in the position of the ex-vivo antenna at ultra-wideband frequencies. It is shown that the location dependent characteristics are not only dependent on the in-vivo devices placed inside the human body but also the position of ex-vivo devices can impact the channel. Results are calculated using the mathematical model and curve fitting technique by calculation of the Root Mean Square Error (RMSE). The statistics of error prediction among the measured data and the proposed model is RMSE = 14.46 for the right lateral and RMSE = 11.63 for the left lateral respectively. These results will help the system designer in accurate link budget calculation for designing enhance implantable devices.

11:10 ***A Statistical Model for On-Body Channels in Indoor Considering Rooms Geometry and Subject Location***

Badre Youssef (Télécom ParisTech-Institut Mines-Télécom & LTCI, France); Manel Berrah (Télécom ParisTech, France); Christophe Roblin (Telecom ParisTech & LTCI - Institut Mines-Télécom, France)

The influence of the surrounding environment on the characteristics of the on-body channel for three radio links of Wireless Body Area Networks is considered in this article. A comprehensive measurement campaign was driven in various rooms focussing on the influence of rooms geometry on the Path Loss, the on-body shadowing and the small scale fading. Simple quantitative models depending on a single parameter representing rooms geometry are proposed.

11:30 ***Magnetic Nanoparticle-Guided Blind-Focusing in Microwave Hyperthermia: Numerical Assessment in the Case of Neck Tumors***

Gennaro Bellizzi (University of Naples Federico II, Italy); Ovidio Mario Bucci (University of Naples, Italy)

This paper concerns with a recently proposed approach of blind focused microwave hyperthermia, exploiting magnetic nanoparticles as contrast agents, and aims at numerically assessing the approach in the clinically relevant case of the treatment of neck tumors. To this respect, a realistic scheme, inspired by the prototypal system called Hypercollar, has been adopted. The well-known Zubal phantom has been exploited as human model. The numerical results show that the proposed approach works well also in a realistic and complex situations like the one considered in this study.

11:50 ***Experimental Study on the Phase Analysis of FMCW Radar for Vital Signs Detection***

Mostafa Alizadeh (University of Waterloo, Canada); George Shaker (University of Waterloo & Spark Tech Labs, Canada); Safieddin Safavi Naeini (University of Waterloo, Canada)

In this work, we address the challenge of the FMCW radar phase analysis known as the phase wrapping. A new solution is proposed based on a recursive phase correction, which does not resort to differentiation or integrations. In addition, the method is implemented and tested for a subject in order to detect heart and breathing rates in a bedroom environment. On the other hand, we derive the cardio-respiration waveforms for the subject to demonstrate the feasibility of using the radar for clinical applications.

12:10 ***Development of a Biometric IntraBody Communication***

Romain Huet (University of Nancy, France); Philippe Levionnais and Olivier Lepetit (Orange, France); Radu Ranta and Valerie Louis (CRAN, France)

The paper presents the development and the evaluation of a biometric device using IntraBody Communication (IBC). The receiver is presented as a mobile phone casing and can be plugged into a smartphone. The emitter is a fixed antenna whose distance to the user hand may vary in time, depending of the user's movements. The main objective of this device's development is to evaluate whether the gesture of approach and contact antenna is an inter-individual signature. A comparison is made between conventional IBC devices and our prototype (called Orange prototype). A way of making a biometric identification is also developed in this paper.

H_A04 Meta & EBG: H_A04 Metamaterials, metasurfaces and EBG

TOP

High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Astrid Algaba Brazález (Ericsson Research, Ericsson AB, Sweden), Traianos Yioultsis (Aristotle University of Thessaloniki, Greece)

10:50 ***Design of Millimetre Wave Phase Shifting Element Using Air-Bridged Schottky Diodes***

Evangelos Vassos, James Churm and Alexandros Feresidis (University of Birmingham, United Kingdom (Great Britain))

A novel design using diodes for tuning periodic phase shifting surfaces at millimetre-wave frequencies is proposed. The presented design consists of a unit cell simulation of a periodic surface with embedded diodes, placed over a ground plane. The tuning is achieved by means of an air-bridged Schottky diode; by varying the reverse bias, the impedance response of the metasurface can be altered, enabled by the variable junction capacitance. Simulations have been carried out using CST Microwave Studio to extract and evaluate reflection losses and the tuning range of the proposed phase shifter.

11:10 ***Correlation Reduction in a 4-Element MIMO Antenna Using Partially Reflective Surface***

Tayyab Hassan (Research Institute for Microwave and Millimeter-Wave Studies, National University of Sciences and Technology, Islamabad); Muhammad Umar Khan (National University of Sciences and Technology & Research Institute for Microwave and Millimeter-Wave Studies, Pakistan); Nosherwan Shoaib (Research Institute for Microwave and Millimeter-Wave Studies (RIMMS) & National University of Sciences and Technology (NUST), Pakistan); Rifaqat Hussain (KFUPM, Saudi Arabia); Mohammad S. Sharawi (Polytechnique Montreal, Canada)

This works presents the reduction of the correlation coefficients in a four element (2x2) multiple-input-multiple-output (MIMO) antenna using a partially reflective surface (PRS). The PRS has a phase gradient in two dimensions and is used above the radiating elements in a Fabry-Perot cavity configuration with reduced height. The system is designed for operation at 10 GHz. The effectiveness of the technique is demonstrated by computing and comparing the correlation coefficients based on far-fields, for with and without the PRS. The proposed structure results in more than 65% reduction in each of the three correlation coefficients, thus projecting enhanced MIMO performance.

11:30 ***A Transmission Metasurface for Generating High-efficiency Broadband Millimeter Wave OAM Beams***

Zhongling Ba (Shanghaitech, P.R. China); Xiong Wang (ShanghaiTech University, P.R. China)

This paper presents a transmission type broadband millimeter wave orbital angular momentum (OAM) generator. A three-layer metallic metasurface structure is proposed to implement the broadband OAM generator. The middle layer mainly modulates the phase of transmitted wave to achieve broadband desired features by properly adjusting dimensions of unit cells. The other two layers are made of metallic gratings that aim to improve transmission efficiency of the metasurface. Two metasurface-based OAM generators with mode numbers of 1 and 2 are designed and simulated. Good transmission efficiency and spiral phase profile are observed in the entire design bandwidth from 55 and 65 GHz. Mode spectra is also calculated to demonstrate the favorable quality of the millimeter wave OAM beams. This work can find potential applications in a bunch of areas like communications and object detection in the millimeter wave regime.

11:50 ***Spherical Active Frequency-Selective Surface for 3-D Beam-Scanning Antenna***

Ali Hassan (SVUIS, Syria); Omran Abbas (Damascus University, Syria)

This paper presents a novel design of active frequency-selective surface (AFSS) in a spherical form where an omnidirectional planar monopole antenna is placed at the sphere's center. The proposed design can achieve beam steering in both the azimuth and elevation planes. Hexagonal cells are used with incorporated high frequency PIN-Diodes to form the spherical (AFSS) surface. Every cell can reflect incident EM waves in the operating frequency band when diodes are in ON state and be transparent when diodes are in OFF state. The antenna beam is formed by activating the appropriate cells and making a dish reflector which is focusing the EM waves in the desired direction. The reflecting dish can be formed freely from any part of the spherical (AFSS) surface for realizing the switched beam antenna.

12:10 ***Implementation of a Compact Ka-band Parallel Plate Luneburg Lens Based on a Hybrid Dielectric/metasurface Unit Cell***

Astrid Algaba Brazález (Ericsson Research, Ericsson AB, Sweden); Lars Manholm and Martin Johansson (Ericsson Research, Sweden); Martin Mattsson and Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

The complete implementation and numerical validation of a compact cost-effective multiport parallel plate Luneburg lens antenna operating at 28 GHz is described in this paper. The lens design consists of two parallel plates separated by a gap where each of them contains a metasurface structure based on a new type of combined dielectric/holey unit cell periodically arranged in a glide-symmetric configuration. The required refractive index is modulated by only varying the height of the holes. The simulations of the final prototype including a flare to ensure a smooth wave transition from the parallel plate configuration to air, as well as a coaxial-to-waveguide-to-parallel plate feeding, show a 20% bandwidth for 11.5 dB return loss, and the crosstalk remains below -15 dB for the same frequency band.

F_A07 Future ant: F_A07 Future antennas

TOP

Future Applications / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Daniele Cavallo (Delft University of Technology, The Netherlands), Paola De Carlo (University of Padova, Italy)

10:50 ***Synthesis Algorithm for "Quasi-Planar" Dielectric Lenses***

Susana Loredo (University of Oviedo, Spain); Germán León (Universidad de Oviedo, Spain)

In this work a phase-only synthesis algorithm based on a planar aperture model is proposed to design "quasi-planar" dielectric lenses with different radiation characteristics, either with a one-beam or two-beam pattern. The model is initially validated with both GO and full-wave simulations, and then with the measurement of a manufactured prototype in anechoic chamber. Both simulations and measurement show good agreement with the model results.

11:10 ***L-band Plasma Turnstile Antenna for GPS Applications***

Giulia Mansutti (Università degli Studi di Padova, Italy); Paola De Carlo, Antonio-D. Capobianco and Davide Melazzi (University of Padova, Italy); Fabio Trezzolani (University of Padua, Italy); Alberto Tuozzi (ASI - Italian Space Agency, Italy)

This work presents the preliminary results of a crossed dipole antenna that works in the L-band and that exploits plasma technology to generate and receive a circularly polarized electromagnetic field. The study considered in a first stage a simplified plasma crossed dipole and successively it included a more realistic design that comprises the plasma generation equipment, more realistic glass vessels and the electrodes used to generate the plasma. The simplified design can achieve good results in terms of axial ratio (i.e., circular polarization), directivity, and input impedance if compared to its metallic counterpart. However, when the more realistic antenna is considered, a down-shift in the operation frequency can be observed. Furthermore, the influence of the plasma parameters on the antenna parameters has been analysed. All the results have been obtained through full-wave numerical simulations in CST Microwave Studio.

11:30 ***Advanced Teaching in EM - Towards an Integration of Theoretical Skills and Applicative/Industrial Skills***

Alessandro Polo (ELEDIA Research Center, University of Trento & ELEDIA Research Center, University of Trento, Italy); Marco Salucci (ELEDIA Research Center, Italy); Angelo Gelmini and Giorgio Gottardi (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Paolo Rocca and Andrea Massa (University of Trento, Italy)

This paper introduces some novel educational approaches and tools for motivating, training, testing the students and supporting the teaching staff in the field of Electromagnetism and Engineering science. The proposed activities have been experimentally validated within Bachelor and Master degree courses by the ELEDIA Research Center, but they are of interest also for the advanced training of industry personnel and usability within product development.

11:50 ***Design of Nonmagnetic All-mode Waveguide Coupler with Perfect Transmission Using Transformation Optics***

Hossein Eskandari (Ferdowsi University of Mashad, Iran); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden); Amir Reza Attari and Mohammad Saeed Majedi (Ferdowsi University of Mashhad, Iran)

Using transformation optics method together with employing the basic properties of Maxwell equations, a compact nonmagnetic waveguide coupler is designed that can ideally couple all TMn modes. Two proposed compression functions provide a perfect smooth transition to the waveguides. This coupler can be used to guide and compress the wave from a vacuum waveguide to a smaller waveguide with a predefined higher dielectric constant. The design method is validated by simulating several examples using COMSOL Multiphysics.

12:10 ***Pascal Arrays***

Goran Molnar and Marko Matijaščić (Ericsson Nikola Tesla d. d. & Research and Development Centre, Croatia)

In antenna array design, linear arrays forming pencil beams are usually considered. For their design, various optimization and analytical methods have been developed. Despite many efficient optimization techniques, the analytical methods are preferable since they ensure fast and robust design. The simplest analytical method is polynomial approximation. In this paper, we propose a class of symmetrical linear arrays that approximate the pencil beam by using the Pascal polynomials. The proposed arrays bring very low far-out sidelobes even for a small number of elements. On the other hand, such sidelobes increase the dynamic range ratio with an increase in the array size. However, for a small number of elements, the ratio is reasonably low. Furthermore, the proposed arrays exhibit higher beam efficiency than do many known low-sidelobe arrays. Such behavior is paid by somewhat wider beamwidth and slightly lower directivity.

Thursday, April 4 13:30 - 15:00

Poster_06: Poster_06

TOP

Wireless Networks and Defense and Security / Poster Session / Antennas

Room: Poster Sessions: P1 - Odra

Chairs: Slawomir J. Ambroziak (Gdansk University of Technology, Poland), Pavel Pechac (Czech Technical University in Prague, Czech Republic)

Poster_06.1 ***Dual Band Printed Monopole Antenna for Wi-Fi Communications Systems***

Tiago Varum (Instituto de Telecomunicações, Portugal); Lucas Leitão and João Matos (Instituto de Telecomunicações, Universidade de Aveiro, Portugal)

The number of connections of wireless communications systems over Wi-Fi networks has grown extensively given the increasing number of equipment's and sensors used by each user nowadays. The need for use other frequency bands to reduce interference and cope with higher data rates led to the allocation, in the recent standards, of two bands at 2.4GHz and 5.2GHz for Wi-Fi networks. In this paper a dual-band printed monopole is presented, with a feed network that allows it to be completely matched along the two operation bands, to be used in the various devices connected to Wi-Fi networks

Poster_06.2 ***Impact of Effective Antenna Pattern on Millimeter Wave System Performance in Real Propagation Environment***

Kamil Bechta (Nokia Networks, Poland); Marcin Rybakowski (Nokia, Poland); Jinfeng Du (Nokia Bell Labs, USA)

Utilization of large antenna arrays in millimeter wave bands is one of the main differentiators in the forthcoming 5G deployment. However, the prevailing simulation practice for inter-site interference and co-existence studies is to use nominal antenna pattern rather than the effective pattern (reshaped by channel angular spread), leading to inaccurate link budget and interference level estimation. We visualize the impact of 3GPP UMa and UMi street canyon channel models on effective antenna array patterns and find that the downlink SINR can be overestimated by 10 to 17 dB when using nominal beam pattern rather than effective pattern.

Poster_06.3 ***Wearable Textile Fractal Tree Antenna for C-band and X-Band Applications***

Paulo Fernandes da Silva Júnior (Universidade Estadual do Maranhão, Brazil); Ewaldo Santana (University of State of Maranhao, Brazil); Alexandre Serres and Edmar Gurjão (UFCG, Brazil); Raimundo Freire (Universidade Federal de Campina Grande - PB, Brazil); Camila Caroline Rodrigues de Albuquerque (Federal University of Campina Grande, Brazil); Paulo Silva (Federal Institute of Education, Science and Technology of Paraíba, Brazil); J. Gilberto Gomes (Instituto Federal da Paraiba, Brazil); Joabson Nogueira de Carvalho (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, IFPB, Brazil)

In this paper is presented a wearable textile fractal tree patch antenna, generated by L-systems for C-Band and X-band application. The proposed structure used L-systems up to 4 interactions, it was built in denim, a wearable, textile and flexible substrate with laminate cooper on top. The antenna works between the C-band (4 - 8 GHz) and the X-band (8 - 12 GHz) frequencies. The proposed fractal tree patch antenna presented a 5.95 GHz bandwidth and a maximum gain of 9.46 dBi.

Poster_06.4 ***Performance Evaluation for Direction of Arrival Estimation Using 4-Element Linear Array***

Murdifi Muhammad (University of Glasgow, Singapore); Minghui Li and Qammer H Abbasi (University of Glasgow, United Kingdom (Great Britain)); Cindy Goh (University of Glasgow, Singapore); Muhammad Ali Imran (University of Glasgow, United Kingdom (Great Britain))

This paper presents the performance evaluation of Direction of Arrival (DOA) estimation techniques such as Root-MUSIC, Root-WSF and Beamspace-ESPRIT (BS-ESPRIT) algorithms under common Wi-Fi conditions such as operating in the IEEE radio frequency spectrum of 5 GHz band, the presence of noise and correlated, closely sourced signals. In addition, we will consider the computational time required for these algorithms to complete the estimation process. Results have shown that the 3 techniques provide a mean of 98.8% accuracy in detecting closely-sourced signals. Although Root-WSF has the longest average computational time of 36.7ms as opposed to BS-ESPRIT and Root-MUSIC at 29.4ms and 22.5ms respectively, Root-WSF technique is the most optimal algorithm in detecting coherent signals with 99.78% accuracy as compared to BS-ESPRIT at 95.27% and Root-MUSIC at 64.77%.

Poster_06.5 ***A Wideband Beam Forming Antenna Array for 802.11Ac and 4.9 GHz***

Moh Chuan Tan (University of Glasgow & RFNet Technologies Pte Ltd, Singapore); Minghui Li, Qammer H Abbasi and Muhammad Ali Imran (University of Glasgow, United Kingdom (Great Britain))

In this work, a wideband high gain 1x4 beamforming (BF) antenna array has been proposed for 5.17 - 5.85 GHz ISM band and extended coverage for 4.92 - 4.98 GHz licensed band. The key antenna performances of 13.6 dBi realized gain, 24.4° Beamwidth, 12.9 dB Sidelobe at 0° beam and ±40° beam steering capability has been achieved. The proposed antenna intended to provide the enhanced wireless link between the ground base station and the mobile terminals with beamforming concept that allow beam steering to focus on targeted direction and null the interference direction with small beam width. The proposed antenna can be further re-configured with different gain and steering beam to cater the dynamic transportation environments.

Poster_06.6 ***New Feed Mechanism for Dual-Polarized Microstrip Ring Patch Antenna***

Po-Kai Wang, Ting-Hung Ko and Jeen-Sheen Row (National Changhua University of Education, Taiwan)

A novel feed mechanism for microstrip patch antennas is presented. The structure of the feed can be regarded as a coaxial balun, and it can be resonant in a one-wavelength loop mode. When the loop mode is properly coupled with the fundamental mode of the microstrip antenna, a broad impedance bandwidth and a symmetrical radiation pattern can be obtained. For the proposed feed, parametric analyses are first performed when it is applied into a square-ring patch antenna. Based on the simulation results, a dual-polarized ring patch antenna is then developed, and its prototype is constructed. Both measured and simulated results indicate that the antenna prototype has a gain of higher than 8 dBi and a cross polarization level of lower than −25 dB within an impedance bandwidth of about 12 %. In addition, the two orthogonal input ports has an isolation level of smaller than −30 dB across the whole operating frequency band.

Poster_06.7 ***Beam Steerable Dipole Antenna Using Varactor Diodes for WiMAX Application***

Ju-Ik Oh and ByungKuon Ahn (KAIST, Korea); Hye-Won Jo (Korean Advanced Institute of Science and Technology, Korea); In-June Hwang (Korea Advanced Institute of Science and Technology(KAIST), Korea); Jong-Won Yu (KAIST, Korea)

This paper presents a beam-steerable dipole antenna using varactor diodes for WiMAX applications. The proposed antenna consists of dipole antenna, two parasitic elements, and varactor diodes. To realize a beam steering feature, varactor diodes are inserted in parasitic elements, which makes the electrical length of the parasitic elements change by adjusting the bias voltage. The proposed antenna can cover wide area in both elevation and azimuth plane by using beam steering feature. For validation of the proposed antenna, simulations were conducted, and the antenna was fabricated and measured.

Poster_06.8 ***From the Characteristic Modes Analysis to the Design of a Radiation Pattern Reconfigurable Antenna***

Zakaria Mahlaoui (Cadi Ayyad University & Universitat Politècnica de València, Spain); Eva Antonino-Daviu (Universitat Politècnica de València, Spain); Adnane Latif (Cadi Ayyad University, Morocco); Miguel Ferrando-Bataller (Universitat Politècnica de València, Spain)

A reconfigurable radiation pattern antenna is proposed. Preliminary investigations are performed with the characteristic modes analysis to understand the physical behavior of the antenna. The presented antenna has the ability to switch from a directional beam to a bidirectional pattern by turning PIN diodes from ON to OFF state. A varactor diode is placed at the top plate to adjust the frequency and match the impedance. A prototype has been designed, fabricated, and measured. Results show good radiation pattern agreement on XZ plane, S11 parameter of the antenna is below −10 dB in the common band from 5.45 to 5.55 GHz.

Poster_06.9 ***Manipulation of Multi-Mode Orbital Angular Momentum Based on Transmission Metasurface***

Kuang Zhang, Yueyi Yuan, Xumin Ding and Guohui Yang (Harbin Institute of Technology, P.R. China); Badreddine Ratni (Univ Paris Nanterre, France); Shah Nawaz Burokur (LEME, France); JiaHui Fu, Wu Qun and Mengxi Wang (Harbin Institute of Technology, P.R. China); Liang Zhang (Jimei University, P.R. China)

In this paper, transmission-type ultra-thin metasurfaces are proposed to generate and manipulate vortex beam carrying multi-mode orbital angular momentum (OAM) in microwave region. By adopting different meta-atoms with regular spatial orientation, phase interruption is introduced to the cross-polarized transmitted wave to manipulate the mode and direction of multi-OAM. The transmission efficiency can reach 80% around working frequency, guaranteeing the high performance of the manipulation of multi-mode OAM.

Poster_06.10 ***Development of a Dual-band Printed Antenna Based on a Nanocomposite Material Made of Polyaniline Charged by Iron-Nickel Nanopowder***

Zahir Hamouda (Institut Aéronautique, Université de Blida, Algeria); Jean-Luc Wojkiewicz (Université Lille Nord de France, France); A Pud (Institut of Bioorganic Chemistry and Petrochemistry of NASU, Ukraine); Lamine Kone (University of Lille, France); S Bergheul (Laboratoire des Sciences Aéronautiques, Université de Blida, Algeria); Tuami Lasri (IEMN - University of Lille, France)

One of the major challenges of printed electronics is to develop materials for flexible devices. Among these latter, antennas occupy a place of choice because of the new applications which are emerging. In this paper a flexible antenna based on a new nanocomposite, Polyaniline (PANI) charged by nanopowder of Iron-Nickel (Fe-Ni), operating in dual-band ([2.4-2.48] and [5.15-5.825] GHz) is proposed. This antenna, triangular/circular shaped with a coplanar waveguide (CPW) feeder to achieve wideband performance is printed on a 130µm thick Kapton® substrate. The nanocomposite fabricated (PANI/Fe-Ni), whose morphology was studied via scanning electron microscopy, has a conductivity of 9600 S/m. The performance of the antenna is analyzed through simulations and measurements which demonstrate a good agreement between each other. A maximum gain of 2.8 dBi for a 90µm thick nanocomposite is obtained.

Poster_06.11 ***Circularly Polarized Annular Slot Antenna Design on Deformed Ground Plane with Top Loading Using Characteristic Modes***

Arka Bhattacharyya and Bhaskar Gupta (Jadavpur University, India)

This work utilizes the effects of deformation of finite ground plane geometry for achieving miniaturization of an embedded slot antenna as well as to obtain circularly polarized radiation using characteristic modes. The antenna is top loaded with a circular patch for gain improvement. Appropriate characteristic modes for the slotted structure are identified and their proper excitation leads to the antenna design.

Poster_06.12 ***Patch Size Optimization for Random Patch RCS Suppression Design***

Yuan-Chang Hou (NTUST, Taiwan); Wen-Jiao Liao and Tzyh-Ghuang Ma (National Taiwan University of Science and Technology, Taiwan); Hsi-Tseng Chou (National Taiwan University, Taiwan)

The suppression of radar cross section is critical to defense platforms. The multilayer phase cancellation structure can achieve more than 20 dB back scattering reduction over a large bandwidth. By adapting the random patch, which avoids forming periodic structure, the applicable incident angle regions can be greatly expanded. However, because patch sizes are in the same order as incidence wavelengths, its interference toward phase cancellation performance is of concern. By observing the back scattering from a single patch, we found the degenerated phase cancellation performance is due to reduced back scattering as the patch length decreases. The minimal patch length requirement is set to ensure its phase cancellation capability. Optimal RCS reduction performance can be therefore derived.

Poster_06.13 ***Optimization of a Flat Directive Antenna for 2.4 GHz Band Using Genetic Algorithm***

Marcello Zucchi (Politecnico di Torino, Italy); Giorgio Giordanengo (Istituto Superiore Mario Boella & Politecnico di Torino, Italy); Marco Righero (LINKS Foundation, Italy); Javier Leonardo Araque Quijano (Universidad Nacional de Colombia, Colombia); Giuseppe Vecchi (Politecnico di Torino, Italy)

This paper presents the automatic design of a novel type of flat directive antenna for the ISM 2.4 GHz band. The optimization is based on a combination of a genetic algorithm (GA) and Method of Moments (MoM) solver. The matrix resulting from the discretization of the antenna is computed once during the setup phase and then used at each iteration, pruning the rows and columns corresponding to parts removed from the antenna. Emphasis is put on the radiated far-field pattern and input matching. As a reference geometry, a square metal plate of size 2λ×2λ at the center frequency of 2.44 GHz is considered, with its surface subdivided into 1016 optimizable sectors. The resulting design is then prototyped and tested for the input matching and directivity.

Poster_06.14 ***Fabrication of a Slotted Waveguide Antenna Based on Gap Waveguide Technology at 440 GHz***

Jorge Teniente-Vallinas (Public University of Navarra & Institute of Smart Cities, Spain); Ruben Caballero-Nagore (Anteral, Spain); Carlos Biurrun-Quel (Universidad Publica de Navarra, Spain); Miguel Ferrando-Rocher (Universitat Politècnica de València, Spain); José Ignacio Herranz-Herruzo (Universidad Politécnica de Valencia, Spain)

A 440 GHz 4x4 slotted-waveguide Antenna fabrication procedure approximation is presented in this paper. The antenna feeding network is based in Groove Gap Waveguide (GGW) technology. The fabrication is intended to be done with Deep Reactive Ion Etching (DRIE) Bosch process in Silicon for the GGW feeding network and Wet Etching also in Silicon for the slots. The resultant slots are in fact tapered apertures with a fixed 54.7° taper angle. The antenna topology is selected to reduce propagation losses inherent to sub-millimetre wave frequencies and the fabrication procedure takes advantage of the silicon etching capabilities we have at Public University of Navarra ISO 7 clean room facility. Wet etching of the 4x4 slot array is selected so as to avoid extremely thin silicon top layer that could bend and ruin alignment efforts. These tapered slots aperture has in fact improved gain and matching of the whole antenna. Also, the GGW feeding network has been redesigned to simplify DRIE manufacturing so as to include only two different etch depths.

Poster_06.15 ***Low-Profile and Wideband Mushroom Antenna with Omnidirectional Radiation Pattern***

Peng Liu and Wen Jiang (Xidian University, P.R. China); Shuxi Gong (National Laboratory of Antennas and Microwave Technology, P.R. China)

A low-profile wideband mushroom antenna based on negative-order resonance (NOR), zeroth-order resonance (ZOR) and positive-order resonance (POR) modes is proposed for unmanned aerial vehicle (UAV) communications. It consists of a circular patch with a set of conductive vias and two circles of mushroom units. The proposed antenna has a low-profile of 0.024λ0 (λ0 is the free space wavelength) at 4.77 GHz. With the NOR, ZOR and POR modes, the antenna obtains an impedance bandwidth (|S11| < -10 dB) of 34.5% (from 4.77 GHz to 6.76 GHz) and has a stable radiation gain. With the conical beam in E-plane and the omnidirectional pattern in H-plane, the antenna is a good candidate for large metallic UAV applications.

Poster_06.16 ***Wideband Planar Tightly Coupled Dipole Transmitarray***

Lin Xiao and Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China); Shi Wen Yang (University of Electronic Science and Technology of china, P.R. China)

A wideband planar tightly coupled dipole transmitarray (TCDT) is presented in this paper. Using receiver-transmitter configuration, the advantages of tightly coupled dipole array are exploited in our design to tackle with the bandwidth limitation of traditional transmitarray element. The interconnected stripline is utilized to compensate the differential spatial phase delay based on the true-time-delay (TTD) concept. The designed unit-cell periodicity is ~ 0.3λ0, where λ0 is the free space wavelength at the highest operating frequency. The simulated results demonstrate that the proposed wideband transmitarray can operate in 9.5~16GHz with stable radiation patterns. To the author's knowledge, it is the first time that a planar tightly coupled dipole transmitarray has been reported.

Poster_06.17 ***Design of a 3D Printed Omnidirectional Antenna for 60 GHz Application***

Philippe Ratajczak (Orange Labs, France)

In this paper, a biconical antenna fed by a rectangular waveguide with a 3D rectangular to coaxial waveguide transition is designed for 60 GHz applications. The proposed transition has a 3D shape that is well suited to be manufactured with a 3D printing process. The antenna provides an omnidirectional coverage in the horizontal plane and works in the frequency band 57.0 to 64.0 GHz. The performances (input impedance, radiation pattern, gain) of the proposed antenna structure are validated by simulations. The finalized structure, after last technical choices, will be manufactured and tested

Poster_06.18 ***A Comparison Between a Modified Two-Ray Model with Atmospheric Effects and the SSPE Method for an EM Propagation Case Study***

Diego Parada (Federal University of Minas Gerais, Brazil); Dinael Guevara (Francisco de Paula Santander University, Colombia); Cássio Rego and Juliana Mendes (Federal University of Minas Gerais, Brazil); Brian Araque (Francisco de Paula Santander University, Colombia); Glaucio L. Ramos (Federal University of São João Del-Rei, Brazil)

This paper presents a comparison between a modified Ray tracing model and the Split Step Parabolic Equation (SSPE) method for a flat terrain problem perfectly conducting and standard atmosphere at 2 GHz. A modified two-ray model showed satisfactory results compared with the SSPE numerical solution when are considered refractive effects of the standard atmosphere.

Poster_06.19 ***3D Antenna Radiation Pattern and Height Effect in Indoor Ray Launching Simulations***

Andres Navarro (Universidad Icesi, Colombia); Dinael Guevara (Francisco de Paula Santander University, Colombia); Alejandro Fornes-Leal (Institute of Telecommunications and Multimedia Applications, Spain)

In this document, we analyze the results of a Ray Lunching tool in an indoor scenario, for 600MHz and 900MHz when the antennas are located at different heights. We show the results of power delay and compare it with measurements for both different heights and same heights, in order to compare the effect of the 3D antenna pattern into the simulation results compared with measurements. Results shows slightly bigger differences in the results between simulation and measurements when antennas are located at different heights.

Poster_06.20 ***Investigation of Antenna Design for Indoor WiFi Energy Scavenging***

Yen-Sheng Chen and Jing-Wei You (National Taipei University of Technology, Taiwan)

In this paper, we analyze the input power of radio-frequency (RF) energy-harvesting antennas that results from various radiation features. Although it is generally believed that this application should select an antenna with an omni-directional radiation pattern, a number of studies have used uni-directional patterns for power reception. To characterize what radiation feature can lead to maximum input power, we implement a technique of ray tracing, evaluating RF power collected by antennas with different half-power beam widths (HPBWs). We put three antennas (HPBW = 30°, HPBW = 60°, and HPBW = 360°) at 12 locations in an indoor environment. Each antenna has 13 × 24 = 312 combinations of orientation. The resultant receiving power is tabulated into a cumulative density function (CDF), and this procedure is repeated for the three antennas. Using the CDFs, we observe that different antennas suit to distinct locations. Thus, it is recommended to develop an adaptive antenna that can be adjusted to suit to different scenario for RF energy scavenging.

Poster_06.21 ***Signal and System Approach for Designing Planar Wideband High Gain Endfire Millimeter Wave Antennas***

Essa Mujammami (Concordia UniversityI, Canada); Abdel R. Sebak (Concordia University, Canada)

A broadband high gain printed Quasi-Yagi antenna with a perturbation-based planar dielectric lens is presented. The perturbation design parameters are based on Nyquist's criteria and diffraction gratings theory for higher order modes suppression, gain enhancement and radiation pattern improvement. The proposed antenna provides 85 % aperture efficiency with a high gain of 16.1 dBi at 34 GHz, high radiation efficiency of 90, and (24-40) GHz ultra-wide, matched impedance, bandwidth. With these features in addition to be low-profile and light weight, this antenna is suitable for various 5G millimeter wave applications.

Poster_06.22 ***Geolocation Spectrum Database - Based TV Spectrum Availability Predictions Versus Measurements for Verulam, South Africa: Overview***

Albert A. Lysko (Council for Industrial and Scientific Research & CSIR Meraka Institute, South Africa); Luzango Mfupe (Council for Scientific and Industrial Research (CSIR), South Africa)

This paper considers the needs to support spectrum availability estimation with reliable real-time information. The discussions are based on a snapshot of television white spaces (TVWS) results captured in Verulam, KwaZulu Natal Province of South Africa and compared against the availability data calculated using a geolocation spectrum database (GLSD). Results indicate possibility of white space prediction accuracy improvements with a real-time monitoring-based feedback and need for careful considerations in setting the monitoring system up

Poster_06.23 ***Indoor Received Power Prediction Based on Physical Optics (PO): Simulations and Experimental Validation in Industrial Environment***

Oleg Iupikov (Chalmers University of Technology, Sweden); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden); Marianna Ivashina, Maja Bärring and Björn Johansson (Chalmers University of Technology, Sweden); Ulrika Engström (Ericsson AB, Sweden); Fredrik Harrysson (RISE, Sweden); Martin Friis (SKF, Sweden); Johan Stahre (Chalmers University of Technology, Sweden)

This study presents an approach based on Physical Optics computations to predict the receive signal power in an indoor environment. The application in focus pertains the development of highly reliable manufacturing industry processes where wireless communications plays a key role. Our proposed numerical method shows a good agreement with measurement data. It is therefore suggested that Electromagnetic modelling based on computationally efficient Physical Optics algorithms can be used as a complement, an alternative or even a replacement for empirical models requiring time consuming measurement campaigns.

Poster_06.24 ***FDTD Modeling of Indoor Propagation with Frequency Averaging***

Stanislav Stefanov Zhekov (Aalborg University, Denmark); Ondřej Franek (Aalborg University & APMS Section, Denmark); Gert Pedersen (Aalborg University, Denmark)

The presence of numerical dispersion and anisotropy in the finite-difference time-domain (FDTD) method leads to an error in the phase of the numerical waves which in turn degrades the accuracy of the simulated electric field (E-field). In this paper, the error in the mean magnitude of the numerical E-field obtained by averaging over frequency is investigated. The central frequency, at which the study is performed, is 3 GHz and different averaging bandwidths are tested to check the accuracy of representing the large-scale fading. By comparing with measurements, it is found that before averaging the maximum error in the numerical results is 64% for empty room and 57% for office scenario. However, the maximum error in the mean magnitude of the FDTD E-field, when averaging over bandwidth of 200 MHz is employed, is 34% and 44% for empty room and office scenario, respectively.

Poster_06.25 ***Ceiling- Or Wall-Mounted Access Points: An Experimental Evaluation for Indoor Millimeter Wave Communications***

Seong Ki Yoo and Lei Zhang (Queen's University Belfast, United Kingdom (Great Britain)); Simon Cotton (Queen's University, Belfast, United Kingdom (Great Britain)); Hien Ngo (Queen's University Belfast, United Kingdom (Great Britain)); William G. Scanlon (Tyndall National Institute, Ireland)

This paper compares the received signal characteristics obtained for two access point (AP) mounting arrangements commonly encountered in indoor millimeter wave wireless networks, namely ceiling- and wall-mounted APs. To facilitate this, we consider three key user equipment (UE) usage scenarios, in which a user imitated making a voice call, operating an app and carrying the device in a pocket. For each of these UE cases, we investigate the fading characteristics of the millimeter wave channel at 60 GHz as the user walk toward and then away from the ceiling- and wall-mounted APs. Following this, the lognormal and κ-μ distributions are shown to provide a good fit to the shadowed and multipath fading, respectively. Based on the parameter estimates and model fitting, it is found that the choice between a ceiling- and wall-mounted position for the AP is dependent on the UE use case and whether the device is in line-of-sight (LOS) or non-LOS (NLOS).

Poster_06.26 ***Scintillation Characteristics from Experiment on 11 GHz Terrestrial Path***

Martin Grabner (Czech Metrology Institute, Czech Republic)

Scintillation of electromagnetic waves is studied by statistical analysis of received power fluctuations measured on the terrestrial microwave path operating in 11 GHz band. The obtained cumulative distributions of standard deviation of attenuation are shown to follow log-normal distribution model. Structure constant of refractive index of air is derived by two methods - from the radio signal fluctuations and from the vertical profiles of meteorological data. A good agreement is achieved between annual statistics of structure constants derived by both methods.

Poster_06.27 ***Asymmetrical-Slot Antenna with Enhanced Gain for Dual-Band Applications***

Adrian Bekasiewicz and Slawomir Koziel (Gdansk University of Technology, Poland)

Dual-band operation is an important feature of antennas to be applied in modern communication systems. Although high gain of radiators is rarely of concern in urban areas with densely located broadcasting stations, it becomes crucial for systems operating in more remote environments. In this work, a dual-band antenna with enhanced bandwidth is proposed. The structure consists of a driven element in the form of an asymmetrical radiator/slot pair suspended over the ground plane. The antenna operates within 2.4 GHz to 3.2 GHz and 4.9 GHz to 6.4 GHz bands with the average gain of 9.7 dBi and 10.4 dBi, respectively. High performance of the structure is achieved through a rigorous two-stage numerical optimization. The antenna lower band covers the industrial, scientific and medical (ISM) radio band which is widely utilized by WiFi, Bluetooth and other systems. The upper band covers all four ranges of the unlicensed national information infrastructure (U-NII) spectrum, applications of which include WiFi 5 GHz, or amateur radio. The proposed structure is compared with other dual-band structures with enhanced gain in terms of size and performance. The effect of the separation between the radiator and ground-plane on the antenna performance is also investigated.

Poster_06.28 ***A Novel Isolation Improvement Technique for Wideband MIMO Antenna Systems***

Muhammad ul Haq (Reykjavik University, Iceland); Slawomir Koziel (Gdansk University of Technology, Poland); Qingsha Cheng (SUSTC, P.R. China)

In this paper, a novel technique for improving element isolation in wideband multiple-input-multiple-output (MIMO) antennas in a parallel configuration is presented. Our methodology is based on ground plane alterations, in particular, introduction of an n-section rectangular slit below the feed line combined with a multi-stage EM-based adjustment of antenna geometry. The technique is demonstrated using a representative set of four wideband MIMO antennas with an intention to analyse the relevance of the approach for various radiator geometries. To maintain a compact antenna size while ensuring acceptable electrical performance, rigorous EM-driven optimization is carried out involving all antenna geometry parameters. The numerical results indicate a clear advantage (in terms of isolation improvement) of increasing the number of the slit sections but also a saturation effect beyond n = 2. The antenna optimization process aims at satisfying two performance specifications: reflection |S11| <= -10 dB, and isolation |S21| <= -20 dB, both within the entire operational bandwidth. Other important figures obtained for the optimized designs, such as Envelop Coefficient Correlation (ECC < 0.005), diversity gain (DG > 9.99 dB), and total efficiency approximately > 80%, confirm suitability of the proposed technique in the context high-performance compact MIMO antenna design.

Poster_06.29 ***Compact Band-pass Filter with RSIW Cavity***

Maraiza dos Santos (Federal University of Campina Grande, Brazil); Raimundo Freire (Universidade Federal de Campina Grande - PB, Brazil); Henry Baudrand (ENSEEIHT, France); Georgina Karla de Freitas Serres and Alexandre Serres (UFCG, Brazil); Samuel Morais (Federal University of Campina Grande, Brazil)

This paper presents a compact band-pass filter with RSIW cavity and CPW transitions. The filter design is based in a single-mode resonant cavity with a ridge symmetrically inserted into the center of the dielectric substrate. The filter was fabricated on a FR4 substrate (εr = 4.2 and tanδ = 0.02) and the metallic vias were connected to the metal surfaces using a silver conductive epoxy, as well as the cylindrical posts of the ridge, that were filled with the same material. This added an efficient and innovative idea for this type of structure. The design was simulated in ANSYS® HFSS. Even though a low cost dielectric was used, the results were satisfactory, achieving a measured insertion loss lower than -3 dB and a return loss of -44 dB with a bandpass of 1.7 GHz; all with a compact physical structure of only 2''x1.38''x0.07'', respectively, length, width and height.

Poster_08: Poster_08

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Future Applications / Poster Session / Antennas

Room: Poster Sessions: P2 - Wisla

Chairs: Thomas Kuerner (Braunschweig Technical University, Germany), Thomas Pairon (Université Catholique de Louvain, Belgium)

Poster_08.1 ***Multiband Corrugated plus Shaped Inverted halfCylindrical Dielectric Resonator Antenna Fornumerous Wireless Applications***

Monika Chauhan (IIITDM & Jabalpur, India); Anil Rajput (PDPM IIITDM Jabalpur, India); Biswajeet Mukherjee (Indian Institute of Information Technology, Design & Manufacturing, Jabalpur, India)

A corrugated plus shaped inverted half cylindrical dielectric resonator (CDRA) antenna is analyzed for wireless applications. Proposed antenna targets IEEE 802.11p standard wireless access in vehicular environments (WAVE) allocated applications bands. Less contact base area to ground plane for inverted half cylindrical DRA & deployed corrugation plays an essential role for enhancement of the bandwidth and gain. In proposed antenna HE11δ, HE12δ, HE123 & HE142 hybrid modes are investigated. The presence of higher order modes contributes to enhancement of the gain. A low loss dielectric material, Rogers TMM10 (εr=10.2) is used to construct the antenna. This antenna attributes cover the multiband frequency responses, it has been operated at 4.5 GHz (4 - 5.5 GHz), 6.75 GHz (6.6 - 6.9 GHz), 7.9 GHz & 11.5 GHz (7.7- 11.8 GHz) resonant frequency respectively. 10.52 dBi peak gain achieved at 8.4 GHz frequency. All the operating band it offered has more than 6 dBi gain.

Poster_08.2 ***A Planar Horn Antenna for TM Surface Wave Launching Using Substrate Integrated Waveguide Technology***

Zain Shafiq and Maksim Kuznetcov (Heriot Watt University, United Kingdom (Great Britain)); Victoria Gómez-Guillamón Buendía (Heriot-Watt University, United Kingdom (Great Britain)); Dimitris E. Anagnostou (Heriot Watt University, United Kingdom (Great Britain)); Symon K. Podilchak (Heriot-Watt University, United Kingdom (Great Britain))

We present a planar substrate integrated waveguide (SIW) horn antenna for efficient TM surface wave (SW) launching at microwave and millimeter-wave frequencies. A design approach is presented by selecting the correct substrate material and operating frequency as well as the SIW horn aperture. In addition, simulations and measurements of a demonstrator prototype for operation at 24 GHz are reported. This type of planar surface wave launcher (SWL) can have multiple applications such as feeding leaky-wave antennas and other SW-based structures. The proposed SIW horn can also be used as a standalone antenna to radiate at end-fire.

Poster_08.3 ***Analysis of Quasi-Periodic Effect in the Design of the Nanorod Metasurfaces***

Hanwei Wang, Maokun Li, Fan Yang and Shenheng Xu (Tsinghua University, P.R. China)

Periodic boundary condition is commonly implemented in element simulation for metasurface design. However, the actual boundary condition deviates from this assumption. This results in phase error from the design. This paper offers a theoretical analysis of the quasi-periodic effect of the nanorod metasurface. Efficiency and element phase error of the metasurface are both studied to evaluate the quasi-periodic effect. The result shows that quasi-periodic effect can induce phase error up to 80 degrees, and efficiency of the metasurface decreases up to 40%.

Poster_08.4 ***Improved Gain Graphene Based Leaky Wave Antenna Loaded by Dielectric Slab in THz Regime***

Zahra Hamzavi-Zarghani (University of Shiraz, Iran & Politecnico di Torino, Italy); Ladislau Matekovits (Politecnico di Torino, Italy); Alireza Yahaghi (University of Shiraz, Iran)

A sinusoidally modulated graphene microstrip line based leaky wave antenna that operates in the THz regime is presented. The dispersion diagram of the unit cell of the antenna is obtained by numerical simulation with commercial software. As a second step, the radiation pattern of the designed leaky wave antenna is calculated: the main beam angle scans with the operating frequency according to the dispersion diagram. To increase the gain, the antenna is loaded with a dielectric slab on top of it acting as a partially reflecting surface. By optimizing the height and distance of the slab, increase in the gain is achieved as it is demonstrated by numerical simulations.

Poster_08.5 ***An Unequal Power Divider Based on Ridge Gap Waveguide***

Yu Quan (Nanjing University of Science and Technology); Jian Yang (Chalmers University of Technology, Sweden); Hao Wang (Nanjing University of Science & Technology, P.R. China); Ashraf Uz Zaman (Chalmers University of Technology, Sweden)

This paper proposes a novel unequal power divider based on the ridge gap waveguide technology. Different from the conventional T-junction power divider, the unequal power divider is realized by using a half-height pin structure with an inserted conductor plane. The conductor plane is printed on a thin substrate for the mechanical feasibility. The power division ratio can be controlled by the position of the inserted conductor plane. In this paper, a 1:2 power divider is designed to verify this topology. The reflection coefficient is below -20 dB from 26 GHz to 32 GHz with 20.7% impedance bandwidth and the amplitude discrepancy between the two output ports is about 2.92 dB. Meanwhile, the maximum value of the phase difference is below 12°.

Poster_08.6 ***Tackling the Issues of Millimeter-wave On-chip Antenna Measurements***

Haoran Zhang and Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

On-chip antennas are becoming more and more important due to the high level of integration and lower costs they offer as part of System-on-Chip solutions. However, the accurate characterization of mm-wave on-chip antenna is difficult because the probe-based measurement is easily influenced by the coupling and interference effects from the integrated circuits and the probe itself. In this paper, the measurement of a monopole on-chip antenna is reported. Then the reasons for the discrepancies in return loss and radiation pattern measurements are analyzed through modified simulation model. Furthermore, we characterize the probe self-radiation pattern and then propose the method of covering the probe with an absorber to improve the measurement accuracy.

Poster_08.7 ***Gain Enhancement of a Substrate Integrated Waveguide Slot Array for Millimeter Waves***

Sondos Mehri (National Engineering School of Sousse ENISo, University of Sousse, Tunisia); Donia Oueslati (ICTEAM Institute, Université Catholique de Louvain, Belgium); Raj Mittra (Penn State University, USA); Hatem Rmili (King Abdulaziz University & Faculty of Engineering, Saudi Arabia)

An approach to enhance the gain of a slot antenna array located on the top wall of a substrate integrated waveguide (SIW) is investigated in this paper. The design procedure consists of two steps. We begin by designing a single slot antenna element located on the top wall of an SIW waveguide, and then we proceed to enlarge it to a full-fledged 4x5 slot array. Following this we further enhance the performance of the array by introducing a Metasurface superstrate above the antenna array. Simulation results are presented for the return loss and gain of the designed array to illustrate its performance. For the unloaded array, a low return loss of less than −10 dB is realized from 27 GHz to 34 GHz with a peak gain of 14.34 dB at 30 GHz. Up to 3 dB gain improvement is achieved, over the bare array, when a Metasurface superstrate is introduced.

Poster_08.8 ***Improving Isolation Between Antenna Array Elements Using Lossy Microstrip Resonators***

Adel Bedair (Egypt-Japan University of Science and Technology, Egypt); Mohamed Aboualalaa (Electronics Research Institute & Egypt-Japan University of Science and Technology, Egypt)

A Quarter-wavelength Lossy microstrip resonator is applied to minimize the mutual coupling between antenna array elements. The proposed lossy resonator is placed between the adjacent E-plane coupled elements in the antenna array to restrict the propagation of surface waves between the antennas of the array. In order to validate the practicability of the proposed structure, a two-element antenna array with half wavelength distance between centers of two patches is designed, fabricated, and measured. The experimental results show a reduction in the mutual coupling of more than 26 dB obtained between elements at the operation frequency of the array.

Poster_08.9 ***Gain-Bandwidth Design Trade-Offs of Broadband Unidirectional Antennas Through Rigorous Numerical Optimization***

Slawomir Koziel and Adrian Bekasiewicz (Gdansk University of Technology, Poland)

In the paper, an optimization-based framework for generating gain-bandwidth trade-off designs for broadband unidirectional antennas has been described. Our approach utilizes sequentially executed constrained optimization runs to yield maximum-gain designs with constraints on impedance bandwidth and gain variability. The optimization routine of choice is trust-region gradient search with implicit constraint handling. The proposed framework is demonstrated by obtaining a set of trade-off designs for a compact wideband quasi-Yagi antenna, indicating its capabilities at various levels of fractional bandwidth. The proposed approach can be useful as a designer's aid as well as a tool for quantitative performance comparison of different (alternative) antenna topologies.

Poster_08.10 ***Optimization of the Use of Magneto-Dielectric Materials for Highly Miniaturized Monopole Antennas***

Aladdin Kabalan (University of Rennes1, France); Ala Sharaiha (Université de Rennes 1 & IETR, France); Anne-Claude Tarot (University of Rennes1, IETR, France)

This article presents the miniaturization of a UWB planar monopole antenna covering the VHF band through the use of low loss Magneto-Dielectric Materials (MDM). By using slots in the antenna structure, the dimensions and position of the MDM have been optimized to reduce the amount of MDM required to obtain an optimum miniaturization rate. This new monopole structure shows a miniaturization rate of 60% by covering about only 5% of the antenna surface area.

Poster_08.11 ***A Broadband Linearly Polarized Beam-splitter***

M. S. Wahidi, Meraj-E- Mustafa, Ramiz Izhar and Farooq A. Tahir (National University of Sciences and Technology, Pakistan)

A broadband electromagnetic beam-splitting metasurface is designed and presented in this paper. This metasurface is composed of two metallic E-shaped patches modeled on FR4 dielectric substrate. The electromagnetic wave when normally incident on the proposed metasurface, it is split into two waves; half of the energy is reflected and the other half is transmitted. Owing to asymmetric nature of the metasurface along x and y-axis, the beam splitting is achieved at 13 GHz for x and at 8 GHz for y polarized wave.

Poster_08.12 ***A Broadband Metasurface for Cross Polarization Conversion Applications***

Meraj-E- Mustafa and Farooq A. Tahir (National University of Sciences and Technology, Pakistan)

A reflective broadband cross polarization conversion (CPC) metasurface operating in microwave frequency regime is simulated and presented in this paper. The metasurface is a periodic arrangement of unit cells and each unit cell consists of a metallic circular split ring resonator (C-SRR) with a circular loop inside it. A linearly-polarized or circularly polarized wave is transformed into its orthogonal counterpart when reflected back from the metasurface. Four plasmonic resonances at different frequencies is the reason behind broadband CPC operation achieving 3dB fractional bandwidth of 107% from 4.2-13.9 GHz. The proposed design has the highest reported 3dB fractional bandwidth made on a lossy single layer FR4 substrate for normal incidence. The designed metasurface is useful in manifold practical applications for polarization control devices.

Poster_08.13 ***Decoupling of Dipole Antenna Array on Patch Type Meta-Surface with C-Shaped Parasitic Element***

Yuki Kawakami (National Institute of Technplogy, Fukui College, Japan); Ryuji Kuse (Kumamoto University, Japan); Toshikazu Hori (University of Fukui, Japan)

A low-profile and decoupling dipole antenna array is achieved by combining a proposed C-Shaped parasitic element and a patch type meta-surface. Based on the moment method analysis results, it is clarified that our proposed parasitic element can suppress mutual coupling between the dipole antenna elements without undesired cross polarized radiation. In addition, the maximum decoupling effect of 15 dB is achieved.

Poster_08.14 ***Design of SIW Resonator Using Epsilon Negative Transmission Line Analysis***

Manoj Prabhakar Mohan, Arokiaswami Alphones and Faeyz Karim (Nanyang Technological University, Singapore)

Substrate Integrated Waveguide (SIW) open circuited resonator is analyzed using waveguide theory and epsilon negative transmission line theory. The resonant frequencies estimated using both the methods have been compared over a wide bandwidth. The SIW open circuited resonator is designed and the simulated and measured results are compared with the resonant frequencies predicted by both the theories.

Poster_08.15 ***2D Agile Beamsteering Using an Electronically Reconfigurable Transmitarray***

João Ricardo Reis (University of South Wales, United Kingdom (Great Britain) & Instituto de Telecomunicações and Polytechnic Institute of Leiria, Portugal); Akram Hammoudeh (University of South Wales Dubai, United Arab Emirates); Nigel Copner (University of South Wales, United Kingdom (Great Britain)); Telmo R. Fernandes (IPLeiria / Institute of Telecommunications & ESTG/IT-DL, Portugal); Rafael F. S. Caldeirinha (Polytechnic Institute of Leiria & Instituto de Telecomunicações, Portugal)

This manuscript introduces an alternative method for 2 Dimensional (2D) fast beamsteering commutation by using a Electronically Reconfigurable Transmitarray (eRT). Supported by previous work carried out by the authors, the performance of a prototyped eRT it is evaluated under the described circumstances. The transmitarray, composed by an artificial lens and an electronic beamsteering controller, allows the main lobe of the radiation pattern of a reference horn antenna to be steered to any desired angle, in both azimuth and elevation planes, in a fraction of a second. Agile beamsteering is accomplished by quickly varying the control voltage at the terminals of varactor diodes present at the surface of each layer that composes the artificial lens. An angular steering rate that can go up to 5kHz was achieved with the prototyped hardware under experimental conditions.

Poster_08.16 ***Investigation of Moisture Influence on Textile PIFA***

Davor Bonefačić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia); Juraj Bartolić (University of Zagreb, Croatia); Branimir Ivšić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia)

The effects of moisture on a textile PIFA have been investigated. Moisture was increased from 0% to 100% and input impedance, radiation patterns and gain were measured. For moisture content larger than 10% the PIFA is significantly detuned. However the antenna gain and radiation patterns are less affected and can be considered acceptable up to a moisture content of 50 %. Silicone-sealant-coated textile pouch was proposed as waterproofing enclosure for the PIFA. The influence of this waterproofing pouch on the PIFA was investigated.

Poster_08.17 ***Pattern Reconfigurable Antenna Applying Spoof Surface Plasmon Polaritons***

Kun Wang (Sahnghai Jiao Tong University, P.R. China); Junping Geng (Shanghai Jiaotong University, P.R. China); Han Zhou, Chaofan Ren and Ronghong Jin (Shanghai Jiao Tong University, P.R. China); Xianling Liang (Shanghai Jiaotong University, P.R. China); Weiren Zhu (Shanghai Jiao Tong University, P.R. China)

In this letter, a radiation pattern reconfigurable antenna based on the spoof surface plasmon polaritons (SSPPs) transmission line is presented. By controlling the phase of two input excitation sources to change the surface current distribution, and obtain two states of operation for SSPPs transmission line, odd mode and even mode. Therefore, the proposed antenna can work in endfire (in the odd mode) and broadside (in the even mode). Simulation results are presented and discussed, the performance verify the proposed design.

Poster_08.18 ***A D-Band Center-Feed Linear Slot Array Antenna Based on Gap Waveguide***

Davoud Zarifi (University of Kashan, Iran); Ali Farahbakhsh (Graduate University of Advanced Technology, Iran); Ashraf Uz Zaman (Chalmers University of Technology, Sweden)

In this paper, the design of a linear slot array antenna based on gap waveguide for D-band applications is investigated. The antenna includes 16 slots and the feeding element is completely based on the ridge gap waveguide. The simulated results on return loss and radiation pattern are presented and discussed. The simulated results show a gain more than 19 dBi and a return loss less than 10 dB over 10% relative bandwidth from 134 to 148 GHz.

Poster_08.19 ***Analysis of Two-Layer Metasuface Using Generalized Sheet Transition Conditions and Babinet's Principle***

Sun-Gyu Lee and Jeong Hae Lee (Hongik University, Korea)

A method to analyze the surface admittance of two-layer metasurface is presented. The two-layer metasurface is modeled by the surface admittance of each layer and transmission line of an air-gap. Generalized sheet transition conditions (GSTCs) and Babinet's principle are used to calculate the surface admittance. The reflection coefficients of the two-layer metasurface were calculated at normal and oblique incidence. The results show that our method well agrees with full-wave simulation, indicating its validity. This method includes angle dependency of the metasurface due to the surface susceptibilities of the normal component.

Poster_08.20 ***Half-Mode SIW Variable PIN Diode Attenuator***

Gabriela Luciani and Jens Bornemann (University of Victoria, Canada)

A half-mode substrate integrated waveguide (HMSIW) variable attenuator for operation in the 6 GHz to 10 GHz frequency range is presented. Different levels of attenuation are achieved by adjusting the level of the dc bias applied to four surface mounted PIN diodes. After fine adjustment of the PIN diode's equivalent circuit, the simulation and measured results are in good agreement, and the initial goal of up to 6 dB attenuation is achieved and verified by measurements of a prototype circuit.

Poster_08.21 ***Extrusion Based High Performance Low Temperature Sintered Ceramic Materials for Microwave Applications***

Shiyu Zhang (Loughborough University, United Kingdom (Great Britain)); Dawei Wang (University of Sheffield, United Kingdom (Great Britain)); Avishek Ghosh, George Chi-Tangyie, Annapoorani Ketharam, Reza Gheisari, Athanasios Goulas, Chih-Kuo Lee, Tom Whittaker and Darren Cadman (Loughborough University, United Kingdom (Great Britain)); Ian Reaney (University of Sheffield, United Kingdom (Great Britain)); Bala Vaidhyanathan, Daniel Engstrom, William Whittow and J (Yiannis) Vardaxoglou (Loughborough University, United Kingdom (Great Britain))

This paper presents 3D printed low temperature sintered (< 700 °C) ceramic materials for microwave applications. The advantages of using cold sintered ceramics include better material compatibility with conductive elements in future multi-material additive manufacturing for microwave devices. Molybdate based ceramics have been synthesized and prepared in slurry form that can be printed by using extrusion based additive manufacturing facilities. Dielectric measurement indicates that the sintered ceramic substrates offer relative permittivity up to 76 with low loss tangents less than 0.001.

Poster_08.22 ***A Dual-Polarized Printed Dipole Antenna with Low Profile for Wideband Base Station Applications***

Zhaorui Zang (Beijing University of Posts and Telecommunications, P.R. China); Ming Su (Being University of Post and Teleommunication, P.R. China); Hongguang Zhang (Beijing University of Posts and Telecommunications, P.R. China); Yuanan Liu (Beijing University of Posts and Telecom, P.R. China)

A compact dual-polarized antenna is presented and fabricated for wideband base station systems. A coupling ring is proposed surrounding two printed dipoles to earn lowprofile property. Similarly, two baluns are loaded to excite the dipoles. By etching some semi-ellipses into baluns, a good impedance performance can be produced. These structures are manufactured on FR4 substrate and the entire dimension is small with a low-profile. Measured results show this antenna has a 36.7% impedance bandwidth (VSWR < 1.5) with a port isolation more than 30 dB. Furthermore, a peak gain of 7.811.3 dBi is achieved. Results show the proposed antenna has potential value to be further studied and used in Base station applications.

Poster_08.23 ***Highly Compact Microstrip Lowpass Filter with Wide Suppression Level Using Diamond and Flag Resonators***

Nisamol A, Abdulla P and Aanandan K (Cochin University of Science & Technology, India); Raphika P M and Jasmine P M (MES College Marampally, India)

This paper presents highly compact lowpass filter with wide stopband and sharp roll-off level using the structure consists of diamond and flag shaped resonators (DSR and FSR) and the results show that the proposed structure is in good agreement with the characteristics. The frequency selectivity of each resonator is utilized to obtain sharp roll-off with low return loss in the stop band. The main attraction towards the proposed structure is its compactness. It can be effectively utilized in areas of research where the space limit is a criterion. Considering all the parameters the fabricated structure can be effectively referred to communication system

Poster_08.24 ***Mitigation of Parasitic Reflections over Periodic Surface Impedance Modulated Panels***

Hassan Haddad (INSA-Rennes, France & Lebanese University, Lebanon); Renaud Loison and Raphael Gillard (IETR & INSA, France); Ali Harmouch (Lebanese University, Faculty of Engineering First Branch El Arz Street Tripoli, Lebanon); Akil Jrad (LEPA, Lebanese University, Faculty of Sciences, Branch 3, Tripoli, Lebanon)

This communication addresses the issue of parasitic reflections from reflecting panels using Surface Impedance Modulation (SIM). These reflections are due to Floquet harmonics appearing because of the periodicity in the modulation. Different SIM panels made of microstrip dipoles are compared at f=8GHz using ANSYS® HFSS®. New metrics are proposed to assess the dipole performance with regards to Harmonic Lobe levels (HLL). Design rules are derived, which permit to mitigate higher order harmonics in unwanted directions.

Poster_08.25 ***Exploiting Channel Hardening and Sphere Hardening for Large Antenna Arrays***

Jocelyn Aulin (Huawei Technologies Sweden AB, Sweden); Said Mikki (University of New Haven, USA)

When transmitting signals with multiple antennas in a region, it has been shown that the transmission medium needs to be modelled in space-time [1]-[3]. From this perspective, we would like to re-examine, using a stochastic MIMO channel model, implications of using large Massive Multiple Input Multiple Output (MIMO) antenna arrays, such as those that extend across a large surface. It is known that the use of linear precoding at a Massive MIMO transmitter enables the received signal at the end user to experience channel hardening, where the signal fading variations approaches zero in the limit as the number of transmit antennas becomes very large. However, the effects of additive noise at the receiver for Massive MIMO systems have not been fully addressed. In this paper, we present a system model that achieves both channel hardening and noise sphere hardening. With channel hardening, the receiver does not need channel state information at the receiver (CSIR), for a sufficiently large transmit array. With receiver noise sphere hardening, the variations of the length of the noise vector is constrained to very small values, enabling error free communication above an average signal-to-noise ratio (SNR), for sufficiently large receive antenna array. Such systems are advantageous for applications with low latency requirements where at a given time instant, data can be received with improved reliability.

Poster_08.26 ***Investigating Correlation of Rough Surface Diffuse Scattering in Frequency Domain***

Yang Miao (Southern University of Science and Technology, P.R. China); Mingming Gan (Huawei, Shanghai, P.R. China); Claude Oestges (Université Catholique de Louvain, Belgium); Katsuyuki Haneda (Aalto University, Finland); Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden); Wei Wang (Chang'an University, P.R. China); Yi Gong (South University of Science and Technology of China, Shenzhen, P.R. China)

This paper investigates numerically the correlation function in the frequency domain due to diffuse scattering originated from rough surfaces. The scattered fields are computed by means of physical optics methods. The irregularities of the rough surface are modeled as a correlated Gaussian process. The correlation of the channel transfer function comprising only diffuse scattering components is analyzed. In the analysis, radio propagation channels comprising orthogonally oriented dipoles at the link ends are considered while assuming different Gaussian roughness profiles. This study offers a useful characterization of the channel behavior in a multipath-rich environment due to diffuse scattering. The presented results are of particular interest to wireless systems based on orthogonal frequency-division multiplexing.

Poster_08.27 ***On the Processing of Loss-Of-Lock Attenuation and Rain Rate Statistics***

George Brost (Air Force Research Laboratory, USA); Kevin Magde (AFRL, USA)

Satellite beacon data is important for development and validation of attenuation prediction models and determining link budgets. The paper examines the impact of how loss-of-lock conditions are processed on the experimental attenuation and rain rate statistics. Not treating loss-of-lock as high attenuation results in a distorted attenuation CCDF up to 20 dB below the dynamic range and a significant underestimate of the exceedance probability

Poster_08.28 ***Effects of Post-Processing Treatments on the Microwave Performance of Additively Manufactured Samples***

Richard Gumbleton (Cardiff University, United Kingdom (Great Britain)); Kenneth Nai (Renishaw PIC, United Kingdom (Great Britain)); Sam Hefford and Adrian Porch (Cardiff University, United Kingdom (Great Britain))

Several flat metal samples, produced by selective laser melting (SLM), have under-gone a variety of post-processing techniques. Microwave surface resistance values at a nominal frequency of 7.5 GHz are used as a comparison between techniques, whilst also performing a comparison against traditionally manufactured copper and aluminium samples. Measured values are then used to create a 3D simulation of a C-Band waveguide filter, utilising measurements from both horizontally and vertically built samples. Overall performance (quantified via low measured surface resistance) was found to be best in the traditionally manufactured copper samples. However silver plating was able to bring some SLM samples to comparable value of low surface resistance.

Poster_08.29 ***Dual-Band, Dual-Fed Self-Diplexing Antenna***

Arvind Kumar (National Institute of Technology, Trichy India & National Institute of Technology, Trichy India, India); Divya Chaturvedi (NIT Trichy, India); Raghavan S (NIT, India)

A compact half-mode substrate integrated waveguide (HMSIW) cavity-backed self-diplexing antenna is demonstrated for 5.2/5.8 GHz applications. HMSIW cavity uses one open-end rectangular slot inserted on the top cladding which divides the cavity into two unequal apertures. Each aperture produces two different resonant frequencies around 5.2 and 5.8 GHz when fed by two discrete microstrip feeds. By appropriately optimizing the antenna dimensions, an isolation of better than 25 dB is realized which aids to introduce the self-diplexing property. The proposed design is realized on a single-layered dielectric substrate with the help of low-cost printed-circuit-board process and experimental study is performed, which shows unidirectional and similar radiations at the both resonances with the respective gain values of 3.23 and 4.38 dBi.

Poster_08.30 ***Selecting Frequency Method of High Frequency Surface Wave Radar Based on EMD and SVM***

Hongzhi Li (Harbin Institute of Technology, P.R. China); Changjun Yu (Harbin Institute of Technology(Weihai), P.R. China); Xin Zhang (Harbin Institute of Technology, P.R. China)

High frequency surface wave radar (HFSWR) works in the shortwave band, and the electromagnetic environment is very complicated, so it is difficult to find a "Quiet Frequency" for ensuring HFSWR work stably for a long time. Frequency monitoring system is introduced into the radar system to provide the best operating frequency real-time. This paper proposes a method based on Empirical mode decomposition (EMD) and Support vector machine (SVM) to forecast the spectrum of the next accumulation cycle, and then get average power spectrum and fluctuation information by sliding window, finally select the best frequency. Through simulation and actual data confirmation, the method forecasts spectrum accurately and works well. It provides a good method to select the optimal frequency in HFSWR.

Poster_Awards: Poster_Awards

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Poster Session

Room: Poster Sessions: P3 - Warta

Chairs: Angelo Freni (Università degli studi Firenze, Italy), Janet O'Neil (ETS-Lindgren, USA)

Poster_Awards.1 ***Probe-Corrected Near-Field to Far-Field Transformation Using Multiple Spherical Wave Expansions***

Fernando Rodríguez Varela (Universidad Politécnica de Madrid, Spain); Belen Galocha (Universidad Politecnica de Madrid, Spain); Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Near-field to far-field transformations constitute a powerful antenna characterization technique for near-field measurement scenarios. In this paper a near-field to far-field transformation technique based on multiple spherical wave expansions is presented. Thanks to its iterative matrix inversion nature, the approach performs the transformation of fields measured on arbitrary surfaces. Also, irregular sampling schemes can be incorporated. The proposed algorithm is based on modelling the antenna fields with not one, but several spherical wave expansions distributed over its geometry. Due to the high number of spherical wave expansions, their truncation number can be arbitrarily reduced. Working with expansions of low order allows to incorporate the probe correction in the transformation in a very simple way, accepting any type of probe and orientation. Only the probe far-field pattern is used, thus working with its full spherical wave expansion is avoided. The algorithm is validated using simulated field data as well as measurements of real antennas.

Poster_Awards.2 ***Smartphone-based Measurements On-Board FSS-aided Railway Vehicles***

Taulant Berisha and Christoph F Mecklenbräuker (Vienna University of Technology, Austria)

It is obvious that railway environments are gaining interest due to their social and economical impact. Today, the main challenge towards seamless connectivity over mobile communications on-board railway vehicles stems from as high as some tens of decibels vehicle penetration loss. To cope with it, frequency selective surfaces are quickly gaining ground as an alternative solution to replace railway vehicle's standard windows which only guarantee protection against infrared and ultraviolet rays. In this study, we performed smartphone-based measurements on-board high speed train with frequency selective surfaces. The experiments were conducted with target to mimic quasi-real usage of end users. All in all, we first evaluated the performance of key performance indicators based on smallscale measurements and then applied nonparametric inferential statistics to assess the service quality of end users in various vehicle placements.

Poster_Awards.3 ***The Effects of a Generator's Active Input Reflection Coefficient in Antenna Gain Measurements***

Kyriakos Kaslis, Olav Breinbjerg and Jeppe Nielsen (Technical University of Denmark, Denmark)

The problem of determining the reflection coefficient of a generator while it is operating is being tackled in this paper, with emphasis placed on both theory and practical applications. Two particular methods are investigated which are, relatively, simple to analyze and implement. It is shown that they have a close agreement despite the widely different procedure by which they approach the same issue. Additionally, the criticality of the generator active input reflection coefficient in determining the gain of an antenna using the gain substitution technique is shown, highlighting the importance to calculate it.

Poster_Awards.4 ***5G mmW Receiver Interoperability with Wi-Fi and LTE Transmissions***

Marko E Leinonen and Marko Sonkki (University of Oulu, Finland); Olli Kursu (Centre for Wireless Communications, University of Oulu, Finland); Aarno Pärssinen (University of Oulu, Finland)

In the future, 5G millimeter wave radios will be integrated into mobile devices and small cell base stations with other radios and this will introduce new interoperability problems. Current LTE (Long Term Evolution) and Wi-Fi radio transceivers have not been designed, verified or specified for simultaneous operation with 5G mmW radios. Wi-Fi or LTE-LAA (Licensed Assisted Access) may introduce co-channel interference due to the harmonics falling over 5G mmW frequencies. Alternatively, the fundamental transmission may block the 5G mmW receiver. This paper studies requirements for RF filtering in the LTE-LAA and Wi-Fi radios, which operate in conjunction with a 5G mmW system. Antenna isolation measurements of 5G proof-of-concept (PoC) antenna array show that mmW antenna array resonates with multiple lower frequencies due to the antenna array physical dimensions, e.g. overall module dimensions, sub-array dimensions and sub-array locations from the edges of the antenna module, leading to new interference problems. Thus, lower frequency interoperability is a new optimization criterion for mmW antenna module dimensions. Measurement results verify that a previously developed 5G mmW POC radio operating at 28 GHz and LTE-LAA/Wi-Fi operating at 5 GHz as well as LTE at 2.7 GHz can operate simultaneously without interference problems within the same radio unit.

Poster_Awards.5 ***Monostatic RCS Prediction from Irregularly Distributed Near-Field Samples Using Plane-Wave Field Synthesis***

Ole Neitz (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

We present an approach to accurately determine the monostatic RCS of an object under test, by measuring a set of bistatic near-field scattering data, where it is sufficient to sample the scattered field in a small angular range around the transmitting antenna. This is achieved by solving a field synthesis problem for the incident plane wave with respect to the transmitter locations and using the result to weight the outcome of a series of inverse source problems. By expanding the fields in propagating plane waves on the unit sphere, almost arbitrary scan surfaces can be processed efficiently, including highly irregular ones. Thus, the measurement samples of the scattered field may potentially be collected by the use of unmanned aerial vehicles and it may even become possible to determine the RCS of large stationary outdoor targets. The paper outlines the theory of the algorithm and demonstrates its capabilities by means of simulated and measured near-field data.

Poster_Awards.6 ***Channel Characterization for mmWave Vehicle-to-Infrastructure Communications in Urban Street Environment***

Danping He and Longhe Wang (Beijing Jiaotong University, P.R. China); Ke Guan (Beijing Jiaotong University, P.R. China & Technische Universität Braunschweig, Germany); Bo Ai (Beijing Jiaotong University & State Key Lab of Rail Traffic Control and Safety, P.R. China); Junhyeong Kim (ETRI & KAIST, Korea); Zhangdui Zhong (Beijing Jiaotong University, P.R. China)

Millimeter wave (mmWave) with large bandwidth is a key technology to support high-data rate vehicle-to-infrastructure (V2I) communications. In this paper, 28 GHz V2I channel is characterized for an urban street in Manhattan. By considering the recommendation in 3GPP TR 37.885, the transmitter is fixed on the street lamp with a height of 10 m, the receivers are mounted on top of the passenger car and bus with a maximum speed of 25 km/h. The ray tracing simulator with calibrated electro-magnetic parameters is employed in this work to practically conduct intensive simulations. The 3D environment model is reconstructed from OpenStreetMap. The key channel parameters, including the power delay profile, path loss, root-mean-square delay spread, K-factor, angular spreads and cross-polarization ratio, are analyzed and compared between different configurations. This work aims to helps the researchers understand the propagation channel for designing mmWave technologies and communication system in a similar scenario.

Poster_Awards.7 ***Joint Delay and Doppler Frequency Estimation for Scatterer Localization in Railway Environments***

Paul Unterhuber, Michael Walter and Nicolas Schneckenburger (German Aerospace Center (DLR), Germany); Thomas Kürner (Technische Universität Braunschweig, Germany)

Autonomous driving vehicles shall increase the efficiency of passenger and goods transportation. Connecting these vehicles and ensuring the reliable exchange of safety critical data is one of the biggest challenges nowadays. The basis of reliable communication between vehicles is a fundamental understanding of the propagation mechanism and the resulting channel models. For the communication between moving vehicles geometry-based stochastic channel models (GSCMs) are widely used to model the non-stationary channel processes. To understand the underlying geometry between transmitter, receiver and scatterers, we propose a joint delay and Doppler frequency estimation to localize scatterer. We use train-to-train (T2T) measurement data and estimate the delay and the Doppler frequency for each measurement of each received signal. The probability density function (PDF) of the joint delay and Doppler frequency estimation is transformed to the Cartesian domain and plotted on a geo-referenced satellite image. In this way, the estimated scatterer position and the related propagation characteristics can be assigned to real objects.

Poster_Awards.8 ***Investigation on Stationarity of V2V Channels in a Highway Scenario***

Daniel Czaniera and Martin Käske (Ilmenau University of Technology, Germany); Gerd Sommerkorn (Technische Universität Ilmenau, Germany); Christian Schneider and Reiner S. Thomä (Ilmenau University of Technology, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Mate Boban (Huawei German Research Center, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany)

This contribution investigates the stationarity of the vehicle to vehicle (V2V) channel in terms of distance and time. Due to high inherent mobility, the channel can not be assumed to follow the wide sense stationary (WSS) and uncorrelated scattering (US) assumption. Therefore, new evaluation methods have to be applied. We assess the stationarity for V2V highway scenarios using the generalized local scattering function (GLSF) and its collinearity based on measurements. We compare results for exemplary traffic situations and investigate the influence of the antenna placements on the stationarity of the channel. Our results yield a strong relation between the stationarity time and the change and rate-of-change of distance between transmitter and receiver.

Poster_Awards.9 ***Experimental Characterization of V2I Radio Channel in a Suburban Environment***

Marwan Yusuf and Emmeric Tanghe (Ghent University, Belgium); Frédéric Challita (University of Lille & IEMN Lab, France); Pierre Laly, Davy P Gaillot and Martine Liénard (University of Lille, France); Bart Lannoo, Rafael Berkvens and Maarten Weyn (University of Antwerp - imec, Belgium); Luc Martens (Ghent University - imec, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper describes the results of the experimental vehicle-to-infrastructure radio channel sounding campaign at 1.35 GHz performed in a suburban environment in Lille, France. Based on the channel measurements acquired in vertical and horizontal polarizations, a multitaper estimator is used to estimate the local scattering function for sequential regions in time, from which Doppler and delay power profiles are deduced. We analyze second order statistics such as delay and Doppler spreads, as well as small-scale fading amplitude. A similar behavior between both polarizations is observed. In both cases, the statistical distributions of the RMS delay and Doppler spreads are best fitted to a lognormal model. The small-scale fading of the strongest path is found to be Rician distributed, while the later delay taps show occasional worse-than-Rayleigh behavior.

Poster_Awards.10 ***System Distortion Model for the Cross-Validation of Millimeter-Wave Channel Sounders***

David G. Michelson (University of British Columbia, Canada); Camillo Gentile (NIST, USA); Andreas Molisch (University of Southern California, USA); Jack Chuang and Anuraag Bodi (NIST, USA); Anmol Bhardwaj (University of British Columbia, Canada); Özgür Özdemir, Wahab Ali Gulzar Khawaja and Ismail Güvenç (North Carolina State University, USA); Zihang Cheng (Tsinghua University, P.R. China); Thomas Choi (University of Southern California, USA); Robert Müller (TU Ilmenau, Germany)

Because millimeter-wave directional channel measurements are time-consuming and expensive to collect, there is considerable interest in combining measurement data obtained with different channel sounders in order to yield more comprehensive datasets. The simplest way to verify that the results obtained with these different instruments in a given environment are comparable would be to transport the channel sounders to that environment, collect and process measurement data, and then compare the results. Because this is rarely feasible, we propose an alternative method that is much more practical. It involves: 1) Generating an ideal three-dimensional channel impulse response that corresponds to a scenario of interest, 2) Degrading the ideal response by applying a distortion model that capture the factors that limit the spatio-temporal resolution and dynamic range of each channel sounder, and 3) Applying the multipath component (MPC) extraction techniques used by the channel sounder to the distorted response. After the last step, one will observe: a) correctly estimated, b) incorrectly estimated, c) missing, and d) spurious MPCs. Discrepancies between the ideal and distorted responses will be readily apparent and the performance of the channel sounders can be easily compared in a given environment. The effort required to fully characterize the three-dimensional patterns of the transmitting and receiving antennas is considerable and further work is required to determine the corresponding accuracy requirements.

Poster_Awards.11 ***Closed-Form Analysis of Artificial Dielectric Layers with Non-Periodic Characteristics***

Daniele Cavallo and Ralph van Schelven (Delft University of Technology, The Netherlands)

We present a general analysis to describe non-periodic artificial dielectric layers (ADLs). Closed-form expressions for the equivalent layer impedance are given for generic plane-wave incidence, assuming that each individual layer can differ from the others in terms of geometrical parameters. By dropping the assumption of identical layers, the given formulas are of more general applicability for flexible designs artificial dielectric slabs that are not uniform along the stratification. The analytical expressions account for the interaction between layers due to higher-order Floquet modes, thus remain valid for arbitrarily small electrical distance between layers.

Poster_Awards.12 ***Characteristic Mode Analysis of User's Effect on Mobile Handset Antennas***

Pasi Ylä-Oijala, Anu Lehtovuori and Rasmus Luomaniemi (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

Theory of characteristic modes is presented for structures with coexisting PEC and lossy dielectric parts. The developed method allows analysis of the radiation properties of the modes and their lossy mechanism. The usefulness of the method for practical antenna design tasks is demonstrated by investigating modes on a PEC plate (antenna ground plane) and an adjacent lossy dielectric structure (user's hand).

Poster_Awards.13 ***Analysis of Curved Metasurfaces with Spatially-Varying Impedance Distribution***

Zvonimir Sipus (University of Zagreb, Croatia); Dominik Barbaric (Ericsson Nikola Tesla dd, Croatia); Marko Bosiljevac (University of Zagreb, Croatia)

Metasurfaces have garnered significant attention in recent years since they act as electromagnetic devices that direct waves, manipulate the polarization of transmitted or reflected waves, or influence the spectrum properties of those waves. Till now most of the attention was focused on the development of planar metasurface structures, however, many demanding electromagnetic applications require the implementation of curved structures. We consider curved metasurfaces that are not homogeneous, i.e. metasurfaces that have spatially-varying distribution of surface sheet impedance. The proposed formulation also covers metasurfaces that do not encompass the entire canonical curved surface. The results are verified through several experimentally characterized cylindrical metasurface examples.

Poster_Awards.14 ***Reconfigurable Split Ring Resonators for Spatial Modulation Communications***

Abdelwaheb Ourir (Institut Langevin ESPCI Paris CNRS, France); Julien de Rosny (Institut Langevin, ESPCI Paris, CNRS, France); Kammel Rachedi (Institut Langevin ESPCI Paris CNRS, France); Dinh-Thuy Phan-Huy (Orange-France Telecom, France)

Very recently, a new concept of low-power consumption and high datarate wireless communication systems appeared. The so-called Spatial Modulation MIMO (SM-MIMO) is based on the ability of the emitter to generate several radiation patterns. We develop a small reconfigurable antenna based on split ring resonators for SM-MIMO. This antenna is able to deliver 8 different radiation patterns at 2.45 GHz. For all of them, a good impedance matching (S11 < - 10 dB) is obtained. The spatial diversity is a key point of SMMIMO. For this purpose, the complex inter-correlation matrix bwteen the 8 states is computed and analyzed. Regarding the SM-MIMO, the bit error rate is assessed versus the Signal to Noise Ratio in a Non-Line-Of-Sight (NLOS) configuration.

Poster_Awards.15 ***Hierarchical Implementation of the Analytical Singularity Evaluation Technique***

Denis Tihon (Université Catholique de Louvain & ICTEAM Institute, Belgium); Christophe Craeye (Université Catholique de Louvain, Belgium)

Using the Method of Moments, the computation of the near-field interactions requires to evaluate 4D singular integrals. Recently, a method has been proposed to compute these integrals fully analytically, rapidly providing accurate results. In this paper, we reformulate the analytical technique to highlight the different intermediate results that are involved in the full procedure. We show that, by storing and reusing intermediate results, the evaluation of the singular integrals is accelerated by several orders of magnitudes.

Poster_Awards.16 ***Design of Bifocal Dual Reflectarray Antennas in Ka-band to Generate a Multi-Spot Coverage from Geostationary Satellites***

Eduardo Martinez-de-Rioja and Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Antonio Pino and Borja Gonzalez-Valdes (University of Vigo, Spain)

This contribution studies the use of bifocal dual reflectarray antennas to provide multi-spot coverage from a geostationary satellite operating in Ka-band. A general 3D bifocal technique has been applied to design a multi-beam dual reflectarray antenna in an offset compact-range configuration, considering three different degrees of beam spacing compression (high, low and no compression) with respect to the equivalent monofocal antenna. The results of the design (bifocal phase distributions, radiation patterns, etc.) have been compared for the three cases under study. The use of suitable reflectarray cells will allow to produce independent beams in each polarization (two beams per feed), so that the bifocal antenna will provide adjacent beams in orthogonal polarizations with 0.56° angular spacing.

Poster_Awards.17 ***Electronically-Steerable Transmitarray Antennas for Ka-Band***

Antonio Clemente (CEA-LETI Minatec, France); Luca Di Palma (Space Engineering S.p.A., Italy); Fatimata Diaby (Polytech School, France); Laurent Dussopt (CEA, LETI, Minatec, France); Trung Kien Pham (University of Rennes 1 & IETR, France); Ronan Sauleau (University of Rennes 1, France)

This paper reports the design and experimental validation of electronically-steerable transmitarrays at Kaband. Two transmitarrays with 20×20 and 14×14 elements have been prototyped and full characterized, for an operation in switchable circular or linear polarization. They are based on 1-bit and 2-bit phase quantization tunable unit-cells, respectively. To control locally the transmission phase on the transmitarray aperture, two or four p-i-n diodes have been integrated on each unit-cell for the 1- or 2-bit designs, respectively. The measured broadside gain at 29 GHz of the 1- bit prototype is equal to 20.8 dBic with a 3-dB relative bandwidth of 14.6%. For the 2-bit architecture, the measured broadside gain at 29 GHz is equal to 19.8 dBi with a 3-dB bandwidth of 16.2%.

Poster_Awards.18 ***Performance of a 28 GHz Two-Stage Rotman Lens Beamformer for Millimeter Wave Cellular Systems***

Muhammad Ali Babar Abbasi (Queen's University Belfast & The Institute of Electronics, Communications and Information Technology (ECIT), United Kingdom (Great Britain)); Harsh Tataria (Lund University, Sweden); Vincent Fusco and Michail Matthaiou (Queen's University Belfast, United Kingdom (Great Britain))

Phase shifter--based hybrid beamforming has received a lot of attention at millimeter--wave frequencies for cellular communications. Nevertheless, the implementation complexity of such beamformers is rather high due to the complexities involved in designing and fabricating the required radio--frequency (RF) circuits. In contrast, lens-based RF beamformers significantly reduce the implementation complexity, as all active circuits can be replaced by a passive device. In this paper, we present the sum spectral efficiency performance of an uplink multiuser multiple-input multiple-output (MU--MIMO) system with a 28 GHz Rotman lens. An asymmetric two-stage stacked design is fabricated with a 15 element 3 x 5 uniform rectangular array feeding 9 RF down--conversion chains towards baseband. Zero-forcing processing is employed at baseband for interference nulling and multistream recovery. Our results show that the MU--MIMO gains are substantially more pronounced for the two--stage architecture relative to a single-stage design due to the inclusion of the elevation multipath components. Moreover, we show that the asymmetric design can help to further reduce the implementation complexity, since the conventional beam selection network can be omitted from the RF front--end.

Poster_Awards.19 ***Wideband In-Lens Polarizer for Future High-Speed Wireless Communications***

Marta Arias Campo (Delft University of Technology, The Netherlands & IMST GmbH, Germany); Darwin Blanco and Giorgio Carluccio (Delft University of Technology, The Netherlands); Simona Bruni and Oliver Litschke (IMST GmbH, Germany); Nuria LLombart (Delft University of Technology, The Netherlands)

The increasing demand for high-speed wireless links requires the development of new approaches for future communication networks. A larger RF bandwidth can be allocated by moving to higher carrier signal frequencies, starting from 100 GHz, allowing for higher data rate capacities. In this contribution, a broadband G-band leaky-wave fed lens antenna with an integrated dielectric grid polarizer is presented. The antenna is able to achieve multiple directive circularly-polarized beams. A quasi-analytical technique based on Spectral Green's Functions combined with a numerical Floquet mode solver is used to optimize the lens aperture efficiency and axial ratio, validating the results via full wave simulations. A design is proposed in low dielectric permittivity material, achieving full-wave simulated aperture efficiency higher than 80% and an axial ratio (AR) lower than 3dB over a 40% relative bandwidth. The feed matching is better than -10dB in the whole frequency band. A prototype has been fabricated, for which first measurement results show promising performance.

Poster_Awards.20 ***Highly Integrated Dual-Band Dual-Polarized Antenna Tile for SAR Applications***

Emilio Arnieri and Luigi Boccia (University of Calabria, Italy); G. Amendola (Universita della Calabria, Italy); Srdjan Glisic (Silicon Radar, Italy); Chun-Xu Mao and Steven Gao (University of Kent, United Kingdom (Great Britain)); Tobias Rommel (German Aerospace Centre (DLR), Germany); Piotr Penkala (Evatronix S.A. Bielsko-Biała, Italy); Milos Krstic (IHP, Germany); Uroschanit Yodprasit (Silicon Radar GmbH, Germany); Oliver Schrape (IHP, Germany); Marwan Younis (German Aerospace Center (DLR), Germany)

The experimental assessment of a highly integrated dual-band (9.6 and 35.75 GHz) dual-polarized antenna tile designed for Synthetic Aperture Radar (SAR) Digital Beam Forming (DBF) satellite applications is presented. Antennas, transitions and down-conversion chips are integrated in the same board fabricated using a customized 15 layer PCB. The experimental assessment proves the validity of the proposed manufacturing and integration approaches, a good agreement between the performance of the individual blocks and of the integrated system has been demonstrated.

Poster_Awards.21 ***The Observable Field for Generalized Incidences***

Arturo Fiorellini Bernardis and Andrea Neto (Delft University of Technology, The Netherlands); Angelo Freni (Università degli studi Firenze, Italy); Nuria LLombart (Delft University of Technology, The Netherlands); Diego Emer (Technische Universiteit Delft, Italy)

The Observable Field is the portion of the incident field that can contribute to the signal received by an antenna. Recently, the Observable Field was estimated for a plane wave incidence. Here, the procedure is extended to a general incident fields expressed as a superposition of multiple plane waves. As a case study we consider a communication scenario which involves a base station and distributed receivers embedded in a complex scattering environment. The Observable Field concept provides clear guidelines for the design of the receiving terminal antennas. In particular, it emerges that to maximize the received power, the pattern in transmission of the antenna should be synthesized to reproduce the angular pattern of the Observable Field. This is specifically relevant in cases of non-line of sight at high frequencies, where the power received can drop by several orders of magnitude.

Poster_Awards.22 ***Equivalent Circuit Models of Finite Slot Antennas***

Ralph van Schelven, Daniele Cavallo and Andrea Neto (Delft University of Technology, The Netherlands)

We propose a systematic approach to describe slot antennas, embedded in generic stratified media. An equivalent transmission line model for the slot is proposed, based on a spectral domain analysis. We introduce a method of moments solution to model semi-infinite or finite slots. The solution entails two basis functions, one at the feed and one at the terminations. The latter basis function is chosen to properly account for the field diffractive behavior at the antenna end points. An approximate circuit model is then introduced, which describes the main mode propagating along the slot as an equivalent transmission line. Lumped impedances are extracted to accurately describe both the reactance of the feed and the termination, and the radiation emerging from these points. This procedure can be used to derive the input impedance of planar antennas with arbitrary length in generic layered media or the interaction between multiple feeds within one slot.

Poster_Awards.23 ***Full-Wave Synthesis of Modulated Metasurface Antennas***

Modeste Bodehou and Christophe Craeye (Université Catholique de Louvain, Belgium); Enrica Martini (Wave Up Srl, Italy); Isabelle Huynen (Université catholique de Louvain, Belgium)

A full-wave synthesis algorithm for modulated metasurface antennas is presented. It is able to provide arbitrary radiation patterns, with any polarization. The algorithm does not use the local periodicity approximation, but is directly based on the electric field integral equation (EFIE). Using Fourier-Bessel basis functions (FBBFs), one can efficiently discretize the surface currents. An inverse problem based on the EFIE is then formulated to derive the surface impedance from the knowledge of the currents. It has been observed that the FBBFs are also more suited than the Zernike basis for the surface impedance discretization. In the case of antenna applications, only the visible part of the surface currents spectrum is known from pattern specifications. This visible part can be combined with the nearfield of the average reactance (SW contribution) to derive the required impedance boundary condition (IBC); this latter is constrained to be anti-Hermitian as required for implementation in the absence of losses. An example of shaped beam design is presented and numerically validated.

Poster_Awards.24 ***Advances in Antenna Measurement and Characterization Using Unmanned Aerial Vehicles***

María García Fernández (University of Oviedo, Spain); Yuri Álvarez and Fernando Las-Heras (Universidad de Oviedo, Spain)

Recent developments in unmanned aerial vehicles (UAVs) hardware and antenna measurement postprocessing techniques have fostered the development of in-situ antenna measurements using UAVs. Accurate geo-referring of the measurements is one of the most critical issues faced by these systems in order to increase the upper working frequency limit. In this contribution a novel methodology based on simultaneous acquisition of the near field (NF) amplitude on two measurement surfaces using a dual-probe setup on board the UAV is presented. Thanks to it, acquisition time and measurement uncertainties are greatly reduced. System capabilities have been validated by measuring an offset reflector antenna, comparing the results with measurements at spherical range in anechoic chamber.

Poster_Awards.25 ***Measurement Based Determination of Parameters for In-stationary TDL Models with Reduced Number of Taps***

Nina Hassan, Martin Käske and Christian Schneider (Ilmenau University of Technology, Germany); Gerd Sommerkorn (Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

This paper proposes a new strategy of extracting parameters for tapped delay line channel models for vehicle to X channels from measurements. The proposed approach is based on an already existing method to derive parameters for a non-stationary tapped delay line model using first-order Markov chains. It will be shown that with a different method of choosing active-taps and the number of taps necessary to regenerate the delay spread of a channel can be significantly reduced. The feasibility of the method will be confirmed using channel sounding measurements.

Thursday, April 4 15:00 - 16:20

Inv_05 Thu: Inv_05 Invited Session 5

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Other / Regular Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Pawel Kabacik (Wroclaw University of Science and Technology, Poland), Giuseppe Vecchi (Politecnico di Torino, Italy)

15:00 ***Optimal Design of Array Antennas for Therapeutic Applications of Electromagnetic Fields***

Ovidio Mario Bucci (University of Naples, Italy)

In medicine, non ionizing electromagnetic fields are exploited both in therapy, to induce some kind of biological effect in a region of interest, and in diagnostics, to obtain information of clinical interest from signals generated in response to an external electromagnetic excitation. This lecture deals with the therapeutic applications of microwaves, in particular with the design of the phased arrays exploited to generate the required fields. The main aim is to enlighten the conceptual points lying behind the optimal design of such apparatuses, putting in evidence the peculiar challenges which must be faced. First, the region of interest is located in the near-field zone of the array, quite always inside it. Second, the region of interest and the array (whose geometry is dictated by the anatomy of the considered part of the body) are usually embedded in a matching medium, which is possibly lossy. Third, the region of interest is an electrically heterogeneous 3-D domain, characterized by high losses, whose features vary from patient to patient. These circumstances entails the need of a reformulation of the classical array synthesis problem, and put absolute limits to the achievable performances. After presenting such reformulation, we review some recent results providing a procedure for addressing, in the case of microwave hyperthermia, the optimal design of the system layout, i.e., the choice of the number and locations of the array elements. We also report some examples to show how the procedure can be carried out in practice, putting in evidence the limits of the achievable performances and the problems which are still open.

15:40 ***Differentially-Fed Dual-Polarized and Shaped Beam Antennas for Satellite Communications***

Quan Xue (South China University of Technology, P.R. China)

Satellite communication and navigation have greatly changed the world. In recent decade, small satellite has become an important trend for satellite technology, making the space on small satellites even more precious. Therefore, highly integrated payloads, such as miniaturized antennas, are in great demand for small satellites. For some special applications, satellite is also required to provide service for a certain area on the earth, which necessitates the radiation beam under a specified shape, such as the earth-coverage-beam antenna. The conventional reflector and phased array designs are bulky and costly, making them unsuitable for small satellites. Therefore, in this speech, a differentially-fed dual-polarized magnetic dipole antenna with a wide beam will be proposed firstly. Then, a compact earth-coverage-beam antenna will be introduced, aiming to realize earth-coverage-beam and provide stable connection within the 100o beamwidth. The compact structure and good performance within the specified beamwidth make the two antennas appropriate for satellite communications.

Inv_06 Thu: Inv_06 Invited Session 6

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Other / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Miloslav Capek (Czech Technical University in Prague, Czech Republic), Andrzej A. Kucharski (Wroclaw University of Technology, Poland)

15:00 ***Joint Design and Co-integration of Antenna-IC Systems***

Marianna Ivashina (Chalmers University of Technology, Sweden)

Conventionally, microwaves and antennas have developed as separate disciplines, using distinct modeling methodologies and relying on good isolation between individually optimized system components. However, the past decade has seen a dramatic departure from classical methodologies towards system-level optimal designs, as needed to meet high-performance demands of future emerging applications (e.g., 5G and future connectivity, autonomous driving, Space exploration). Antenna systems for such applications typically involve arrays of many antenna elements and active front ends, with power amplifiers (PAs) and low noise amplifiers (LNAs) in the proximity to the antenna or even integrated with the antenna. Such systems require a combined circuit-electromagnetic modeling approach, and these are nonreciprocal. Furthermore, array beamforming and signal processing should be considered from the start to enable full system analysis and design optimization. I will present a modern approach to the design of active beamforming array antennas in the receiving situation that reflects the state-of-the-art in the academic literature and is included in the new textbook 'Phased Arrays for Radio Astronomy, Remote Sensing, and Satellite Communications,' Cambridge, July 2018, published in collaboration between Profs. K.F. Warnick (BYU), R. Maaskant (Chalmers), D.B. Davidson (Stellenbosch/Curtin), B.D. Jeffs (BYU), and this presenter. Techniques for the optimal noise match of a multi-channel receiver to an array antenna, in the presence of antenna mutual coupling effects and associated noise coupling phenomena, will be discussed. This includes trade-offs, common misconceptions, and practical examples. Afterwards, the latest studies highlighting some of the current research involving circuit-antenna co-integration solutions for active beamforming transmitting array antennas will be presented. I will focus on integration strategies which are tailored to high-efficiency PA architectures and suited for applications with demanding performance requirements (e.g. the next generation mobile systems at sub-6GHz and mm-wave frequencies). An antenna-integrated high-efficiency (Doherty) PA utilizing active load modulation will be taken as an on-antenna power combining example, including optimization aspects and over-the-air characterization methods. Other examples will cover novel mm-wave circuit-antenna transitions employing a direct antenna-PA impedance matching technique.

15:40 ***Metasurfaces: From Numerical Models to EM Devices***

Stefano Maci (University of Siena, Italy)

Metasurfaces constitute a class of thin metamaterials, which can be used from microwave to optical frequencies to create new electromagnetic engineering devices. At microwave regime they are obtained by a dense periodic texture of small elements printed in a stratified medium. Changing the dimensions of the elements, being the sub-wavelength 2D-periodicity equal, gives the visual effect of a pixelated image and the electromagnetic effect of a modulation of the equivalent local reactance. The modulated metasurface reactance so obtained is able to transform space, surface or guided waves into different wavefield configurations with required properties. The modulation of the metasurface reactance allows for a local modification of the dispersion equation and, at constant operating frequency, of the local wavevector. We may identify three main design of MTSs, in which the objective is to control: (i) space-wave; (ii) leaky-wave, and (iii) surface wave. The first type of MTSs control impinging spatial waves by refracting, deflecting, focusing or controlling the polarization of an impinging space wave. The second class of MTS is designed in order to convert a bounded surface wave (SW) into a curvilinear wavefront leaky-wave (LW), where impedance BCs are modulated in a locally-periodic fashion. MTSs for SWs manipulation control their propagation path, changing the SW wavefront. Combining these different design into microwave devices IThis presentation will start from the basic theory and illustrates numerical models in a design loop, to end-up to several new design of high-gain, low cross-pol antennas, Gaussian horns, multibeams, lenses, deflector, metaradomes and ultrawideband antennas. Examples of adaptive MTSs, composed of dynamically reconfigurable materials, would allow to explore new reconfigurable-beam antennas all be also shown.

Thursday, April 4 16:50 - 18:30

CS3 Gen MoM-based Eigen Probl: CS3 Generalized MoM-based eigenvalue problems for antennas and scattering

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Methods & Tools / Convened Session / Antennas

Room: Oral Sessions: S1 - Krakow

Chairs: Mats Gustafsson (Lund University, Sweden), Kurt Schab (Santa Clara University, USA)

16:50 ***Generalized Theory of Characteristic Modes for non-PEC Media***

Pasi Ylä-Oijala, Henrik Wallén, Dimitrios C Tzarouchis, Seppo Järvenpää and Ari Sihvola (Aalto University, Finland)

Generalized theory of characteristic modes is proposed for the PMCHWT integral equation formulation of a homogeneous penetrable body. By properly expressing the weighting operator of the generalized eigenvalue equation in terms of the external radiation-related integral operators, any symmetrization or other modifications of the equations is not needed. Numerical examples are presented to demonstrate the validity of the proposed method. The obtained characteristic modes are shown to have the desired properties of physically meaningful eigenvalues and orthogonal far field patterns.

17:10 ***Modal Crossing Treatment Using Group Theory***

Michal Masek, Miloslav Capek and Lukas Jelinek (Czech Technical University in Prague, Czech Republic); Kurt Schab (Santa Clara University, Santa Clara, USA)

Detecting modal crossings and crossing avoidances between eigenvalue traces in modal tracking is solved based on group theory. Rules based on the presence of symmetry are applied to predictively determine mode behavior over a frequency range. The procedure can be used for a large class of generalized eigenvalue problems and is demonstrated by an example of characteristic modes. An approach leveraging this procedure to accelerate computation is also discussed.

17:30 ***A Comparison Between QCQP-relaxation Methods to Determine a Lower Bound on a Small Antenna Q-factor***

Lars Jonsson (KTH Royal Institute of Technology, Sweden)

Quadratically constrained quadratic programming (QCQP) can be used to determine the best Q-factor for small antennas with constraints on the antenna efficiency. Constraints on the total directivity and a given front-to-back ratio can also be expressed as QCQP. Such problems are non-convex and hence challenging to solve. Their solution gives the best Q-factor available for any antenna within the considered volume. Thus this type of problem solution provide a tool, that before the design, can predict the best possible antenna performance within a given volume of a device. It is hence important to investigate methods to solve this class of QCQP problems. In this paper we compare and investigate two relaxation methods, the Lagrangian dual and semidefinite relaxation, to estimate lower bounds on the Q-factor. The former method is here reduced to solving a generalized eigenvalue-problem. Properties of the different relaxation methods are illustrated and compared. We focus on in this paper Q-factor and its relation to efficiency, as expressed by the dissipation factor. However, these tools also apply to a larger class of problems including constraints on the directivity and other far-field conditions.

17:50 ***Characteristic Mode Analysis of Planar Dipole Antennas***

Hanieh Aliakbari and Buon Kiong Lau (Lund University, Sweden)

Planar monopole antennas are popular due to their attractive properties, but their operating mechanisms are still not well understood. Based on image theory, planar monopoles can be analyzed using their dipole counterparts. Here, the bandwidth and radiation pattern of planar dipoles is studied in detail using characteristic mode analysis for different design parameters. The results show that insignificant modes can help to improve the bandwidth without contributing to the radiation property. Moreover, a tradeoff is observed between pattern stability and impedance bandwidth as the dipole width varies. Furthermore, it is found that an offset in the feed point leads to a degradation in both the modal and impedance bandwidths.

18:10 ***Augmenting Characteristic Mode Orthogonality via Iteratively Applied Constraints***

Kurt Schab (Santa Clara University, USA); Miloslav Capek (Czech Technical University in Prague, Czech Republic); Mats Gustafsson (Lund University, Sweden)

Affine constraints are iteratively applied to enforce multiple orthogonality conditions on currents satisfying a general eigenvalue problem. As an example, the characteristic mode eigenvalue problem is iteratively solved with constraints simultaneously enforcing orthogonality in the loss, radiation, and reactance operators. The resulting modes share many properties with standard characteristic modes.

CS6 AMTA: Sat&Aerosp Ant Meas CS6 AMTA session: Satellite and Aerospace Antenna Measurements

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Space / Convened Session / Measurements

Room: Oral Sessions: S2 – Warszawa

Chairs: Tao Huang (Oxford Space Systems, United Kingdom (Great Britain)), Christian Hunscher (Airbus DS GmbH, Germany)

16:50 ***NISAR Flight Feed Assembly Measurement Campaign***

Paolo Focardi (Jet Propulsion Laboratory & California Institute of Technology, USA)

NISAR (NASA ISRO SAR, National Aeronautics and Space Administration, Indian Space Research Organization, Synthetic Aperture Radar) is an Earth science project currently in its final development phase at NASA Jet Propulsion Laboratory (JPL) and at ISRO. Due for launch in 2022, it will assess how our planet changes overtime by measuring differences in the Earth's solid surface due to factors like climate change, movement and melting of glaciers, earthquakes, land-slides, deforestation, agriculture and others. The enabling instrument for this mission is a dual band radar (L-Band and S-Band) that feeds a 12m deployable mesh reflector. This paper describes the antenna measurement campaign of the L-Band feed array developed at JPL. The S-Band feed array is developed by ISRO and is not part of this paper. While Measurements of the Engineering Model have been published before, this paper focuses on the first measurements done with the Flight Model.

17:10 ***Fast Measurement Methodology for near Field Satellite Testing***

Francesco D'Agostino, Flaminio Ferrara, Claudio Gennarelli and Rocco Guerriero (University of Salerno, Italy); Maria Alberica Saporetti, Francesco Saccardi and Lars Foged (Microwave Vision Italy, Italy); Damiano Trenta (European Space Agency, ESTEC, Italy)

In this paper, we present a fast measurement methodology applicable to near field testing of satellite in planar and spherical geometry using non-canonical scanning and irregular sampling. The planar measurements have been accomplished by the planar wide-mesh scanning approach, while the spherical measurements have been performed at the points of a nonredundant raster grid. In this grid, the number of the sampling parallels, as well as of the sampling point on them are drastically reduced. Both the nonredundant sampling representations are based on the two-bowls modelling of the antenna under test. Different test cases from satellite telecommunication (ku-band highly-shaped and pencil beam reflectors and navigation antenna) are presented . The Near-Field to Far-Field transformation accuracy of the fast methodology has been investigated The time improvement factor of the new measurement methodology is dependent on the antenna under test and ranges from a minimum of 2.6 to a maximum of 7.5.

17:30 ***Advances in Characterizing Complex Frequency Responses of Frequency Converting Payloads in Planar Near-Field Test Ranges***

Patrick Pelland (NSI-MI Technologies, USA); Daniël Janse van Rensburg (NSI-MI Technologies & Nearfield Systems Inc, USA); Edwin Barry (ARL, USA)

This paper provides an overview of a planar near-field test methodology for measuring typical system level characteristics of transceiver payloads. Measuring parameters such antenna gain, equivalent isotropic radiated power, saturating flux density, group delay and channel frequency response is the objective. We describe how transfer functions are derived for the antennas in question, allowing one to compensate for the fact that measurements are being performed in the near-field of both uplink and downlink antennas. Practical implementation aspects like near-field probe selection, probe positioning and RF sub-system modification are addressed. We also present a concept simulated payload, since this is critical to system verification and facility-to-facility comparison.

17:50 ***Interlaboratory Millimeter-Wave Channel Sounder Verification***

Jeanne Quimby (NIST, USA); David G. Michelson (University of British Columbia, Canada); Mustahpha Bennai (Communications Research Centre, Canada); Kate A. Remley, Joshua Kast and Alec Weiss (NIST, USA)

The channel sounder verification program within the National Institute of Standards and Technology-coordinated 5G mmWave Channel Model Alliance aims to place channel sounders on a sound metrological foundation by using well-established laboratory verification methods coupled with modern waveform metrology tools. To provide comparison-to-reference verification of channel sounder hardware measurements, we begin by measuring deterministic conducted channels, established using a channel sounder verification artifact and temperature control unit. This artifact produces multiple stable and repeatable environments to compare the channel sounders' hardware performance to a reference measurement provided by a vector network analyzer. The reference vector network analyzer measurements have an uncertainty analysis including systematic and random components to verify the channel sounder performance. General insights and common problems are provided using measurements of the verification box from a range of channel sounders in the Alliance.

18:10 ***An Effective Phaseless NF Antenna Measurement Approach***

Amedeo Capozzoli, Claudio Curcio, Giuseppe D'Elia and Angelo Liseno (Università di Napoli Federico II, Italy)

Recently, a phaseless near-field antenna characterization approach has been proposed. It exploits an "effective" representation of the unknowns, able to reduce the overall number of parameters to be sought for and with signicant beneficial effects on both accuracy and reliability. At the same time, on taking advantage of the a priori information on the scanning geometry through a non-uniform sampling of the nearfield, beneficial effects are obtained on the stability of the inversion process, on the rejection of the environmental clutter and on significantly reducing the overall number of near-field phaseless measurements to be performed. Experimental results at 75 and 94GHz concerning the nearfield phaseless characterization of millimetre-wave antennas are presented. The results results show the feasibility of phaseless antenna characterization also in the millimetre frequency range. The aim of this paper is to numerically point out the accuracy and reliability of the proposed algorithm, with particular reference to millimeter-wave applications.

F_A03 MM, Sub-mm & THz Ant: F_A03 Millimeter, sub-millimeter and TeraHertz antennas

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Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Paweł R. Bajurko (Warsaw University of Technology, Poland), Adam Narbudowicz (Wroclaw University of Science and Technology, Poland & TU Dublin, Ireland)

16:50 ***Wideband Low-Profile Aperture Antenna for 5G- Applications Comprising of a Slotted Waveguide Array and an Integrated Corporate Feed***

Donia Oueslati (ICTEAM Institute, Université Catholique de Louvain, Belgium); Raj Mittra (Penn State University, USA); Hatem Rmili (King Abdulaziz University & Faculty of Engineering, Saudi Arabia)

This paper presents a design of a low-profile high gain aperture array antenna for 5G-Network communication applications (Ka-band). The antenna is comprised of a slotted waveguide array with an integrated wideband feed, and its low-profile makes it a good candidate as a replacement of a reflector, a flat lens or a reflectarray. The array is designed by using a waveguide antenna with 10 slots and a single feed. The waveguide antenna is proposed as a unit element of the aperture array. The prototype of a 4x10 waveguide array antenna has been simulated by using the EM solver "HFSS". The array is excited by using a wideband 4:1 power divider. The aperture array achieves an impedance bandwidth of 70.75% by using matching networks, a low side lobe level and a high gain at an operating frequency of 30 GHz, which is further enhanced by using a dielectric superstrate layer.

17:10 ***Pulsed Photoconductive Connected Array for Generating mW Average Power in the Sub-Mm Wavelength Band***

Alessandro Garufo (TNO & Delft University of Technology, The Netherlands); Paolo Sberna and Giorgio Carluccio (Delft University of Technology, The Netherlands); Joshua R Freeman (University of Leeds, United Kingdom (Great Britain)); Dave Bacon (University of Leeds, The Netherlands); Juan Bueno (SRON Netherlands Institute for Space Research, The Netherlands); Jochem Baselmans (SRON, The Netherlands); E. Linfield (School of Electronic and Electrical Engineering, University of Leeds, United Kingdom (Great Britain)); Alexander Davies (University of Leeds, United Kingdom (Great Britain)); Nuria LLombart and Andrea Neto (Delft University of Technology, The Netherlands)

A novel pulsed photoconductive THz source is presented that is able to radiate mW-level average powers, over a large bandwidth by exploiting both the optical and electrical properties of photoconductive sources and the ultrawideband properties of connected antenna arrays. An optical system composed of a micro-lenses array splits the laser beam into N x N spots that host the active excitation of the antenna arrays. An "ad hoc" network is introduced to bias the array active spots in order to implement a connected antenna array configuration. The array feeds a silicon lens to increase the directivity of the radiated THz beam. A dipole and a slot array are designed. Prototypes have been fabricated and measured. Power and spectrum measurements of the prototypes are in excellent agreement with the expected results. The proposed solutions achieve excellent power radiation levels by exploiting accurate electromagnetic design. Thus, they can offer enhancements to any active system relying on pulsed photoconductive antennas.

17:30 ***Generation of Broadband THz Airy Beams Applying 3D Printing Technique***

Dajun Zhang and Beng Chen (ShanghaiTech University, P.R. China); Zhongling Ba (Shanghaitech, P.R. China); Shuo Ni (ShanghaiTech University, P.R. China); Juncheng Cao (Shanghai Institute of Microsystem and Information Technology, P.R. China); Xiong Wang (ShanghaiTech University, P.R. China)

Non-diffraction beams like Airy beams have been widely explored in various disciplines owing to its fascinating features. A broadband generator for THz Airy beam operating from 90 to 110 GHz is investigated in this work. It is composed of three lenses and fabricated by 3D printing technique using polymer. Experimental characterization is conducted to validate the effectiveness of the fabricated Airy beam generator. Obvious curved propagation trajectory of the Airy beam is observed in the operation bandwidth, implying successful generation of the broadband Airy beam. Potential applications like broadband THz wave manipulation and imaging can be developed based on the proposed technique.

17:50 ***A 120 GHz Antenna for LTCC Package with Via-Less Contact Pads for Probe Measurements***

Jakub Sobolewski and Paweł R. Bajurko (Warsaw University of Technology, Poland)

This paper presents two 120 GHz Low Temperature Co-fired Ceramics (LTCC) antenna designs with eliminated metallic connections (vias) between structure's layers. The first design is a single element rectangular patch antenna while second is a two element series-fed patch antenna array. Elimination of vias provided more robust construction less susceptible to identified manufacturing issues of mm-Wave devices in LTCC. Presented antennas were manufactured using substrate materials and techniques of „zero shrinkage" LTCC process, significantly improving quality of the structures. Measurements of the structures showed all samples operating similarly to simulated results with slight de-tuning, even though no additional processing like laser ablation was used to enhance screen printing resolution. Different influence of surface roughness compared to microstrip lines was also observed.

18:10 ***An Investigation of THz Backscattered Side-Channels Measurement at a Distance***

Sinan Adibelli (Georgia Institute of Technology, USA); Chia-Lin Cheng (Georgia Tech, USA); Prateek Juyal and Alenka Zajic (Georgia Institute of Technology, USA)

This paper presents the measurement setup and the investigation on the backscatter side-channel signal detected and received, at 300GHz, from an activated FPGA board. First, the ellipsoidal reflector, used as an incident source, with a spot size of 0.7mm is designed and fabricated. Next, a region on the FPGA chip is divided geometrically into various cells with cell dimensions corresponding to reflector spot size. Finally, it was shown that the backscatter side-channel signal can be detected by a diagonal horn antenna placed at a distance from the FPGA board. The received signal behavior is investigated in terms of absolute signal strength, measured noise power level and signal to noise ratio. This provides deeper insight into the detected backscatter side-channel emanating from the FPGA board.

F_A20 Frequency and PSS: F_A20 Frequency and polarization selective surfaces TOP

Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Raymond Dickie (Queens University Belfast, United Kingdom (Great Britain)), Alfrêdo Gomes Neto (Instituto Federal da Paraíba - IFPB & Grupo de Telecomunicações e Eletromagnetismo Aplicado - GTEMA, Brazil)

16:50 ***A Miniaturized Stop-Band Frequency Selective Surface Based on Sub-wavelength Slow-Wave Dipole***

Da Yi and Xing-Chang Wei (Zhejiang University, P.R. China); Yan-Bin Yang (Zigong Innovation Center, Zhejiang University, P.R. China)

This work introduces a novel band-stop frequency selective surface (FSS) based on slow-wave dipoles. By controlling the dispersion of the slow-wave structure, the working frequency of the FSS could be controlled within 3 to 5 GHz without altering the dipole length. Beneficial from the slow-wave property, this design could reduce 18% length of the traditional rectangular dipole unit cell and eliminate the grating lobe effect.

17:10 ***Varactor-Tunable Four Arms Star Bandstop FSS with a Very Simple Bias Circuit***

Alfrêdo Gomes Neto (Instituto Federal da Paraíba - IFPB & Grupo de Telecomunicações e Eletromagnetismo Aplicado - GTEMA, Brazil); Jefferson Costa Silva (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba & IFPB, Brazil); Amanda Barboza (Federal Institute of Paraíba, IFPB, Brazil); Deisy Mamedes (Federal Institute of Education, Science and Technology of Paraíba & GTEMA, Brazil); Ianes Coutinho (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba (IFPB), Brazil); Marina Alencar (IFPB, Brazil)

In this paper a varactor-tunable bandstop FSS based on the four arms star geometry is presented. Besides the resonant frequency tuning, an interesting feature is that practically no bias circuit is required. The four arms star geometry is described, including initial design equations. The adopted varactor model is depicted. A FSS prototype is designed, fabricated and characterized, with numerical and experimental results, observing a good agreement. Despite the simplicity of the considered varactor model, the difference of 6.5% between numerical and experimental results, could be easily decreased, adapting the capacitance value, but this fine adjust it is not the objective of this work. The varactor-tunable bandstop FSS prototype achieved a resonant frequency varying from 3.4 GHz to 3.8 GHz. With the herein proposed FSS, using appropriate varactors and basic cell dimensions, different resonant frequency ranges can be obtained, a very attractive characteristic, with potential applications in the current telecommunication systems.

17:30 ***Silver Nanowires Based Transparent, Broadband FSS Microwave Absorber***

Weiwei Li (KAUST, Saudi Arabia); Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

An optically transparent microwave absorber with broadband absorption based on frequency selective surface (FSS) have been proposed and fabricated using a simple, cost-effective, and controllable inkjet printing assisted patterning technique. The FSS and ground layers are made of silver nanowires (AgNWs) conductive networks with desired patterns. This new device exhibits broadband absorption performance with an optimized 90% absorption bandwidth over the frequency range of 9.1 to 12.2 GHz in X-band. Besides, due to the patterning of AgNWs FSS and ground layers, the optical transmittance of the fabricated absorber exceeds 83% at 550 nm wavelength, which is the highest among the transparent absorbers in literature. Based on the easy-processing, high performance, and excellent transparency, the proposed absorber shows great promise for various applications relating to transparent absorbers, such as photonic detectors, antennas, and solar cells.

17:50 ***New Electronic Switching Arrangement for (sub)mm-Wave Radiometer Calibration***

Raymond Dickie and Robert Cahill (Queens University Belfast, United Kingdom (Great Britain))

This paper describes a new quasi-optical switching method for more efficient calibration of millimetre and submillimetre wave Earth Observation (EO) radiometers. Passive remote sensing instruments must be calibrated regularly to ensure high measurement accuracy and current systems require switching between known hot and cold reference target loads using large and heavy power hungry motor driven mechanical systems. The proposed switching method is based on a reconfigurable Frequency Selective Surface (FSS) which is composed of a thin dielectric slab placed above a periodic array of polarisation independent slot elements. The spacing between the FSS and the high permittivity dielectric is adjusted to provide a good impedance match to free-space and hence high transmission for the 'ON' state, whereas for the 'OFF' state the separation distance is chosen to degrade the match and hence suppress the signal transmission by -30 dB mid band. Numerical predictions and experimental results in the frequency range 316 - 334 GHz are presented to demonstrate the operation of the FSS switch.

18:10 ***Sensitivity of Frequency Selective Surfaces Made on Dielectric Substrate to Thermal Loads***

Pawel Kabacik, Arkadiusz Byndas and Mariusz Hofman (Wroclaw University of Science and Technology, Poland)

Frequency Selective Surfaces (FSS) can find important applications in remote monitoring, nondestructive inspections and process automation in a case FSS electromagnetic structure become able to reveal their deformation due to mechanical and thermal loads in a remotely measurable form. In this paper we present results of our investigations into split elliptic FSS strcutures exposed to high thermal loads

C_P03 MMWave Propag: C_P03 Millimetre-wave propagation for wireless networks

TOP

Cellular Communications / Regular Session / Propagation

Room: Oral Sessions: S4-A - Poznan

Chairs: Andrew C M Austin (The University of Auckland, New Zealand), Jose M Riera (Universidad Politécnica de Madrid, Spain)

16:50 ***60 GHz Millimetre-Wave Channel Characterisation for Indoor Office Environments***

Andrew C M Austin, Damla Guven, Michael J Neve and Kevin W Sowerby (The University of Auckland, New Zealand)

A 60 GHz swept-tone channel sounder with 1 GHz measurement bandwidth has been developed. The sounder has been used to analyse millimetre-wave propagation in a compact indoor office environment. Profiles of the power angle-of-arrival have been measured for a number of different transmitter and receiver configurations to identify the dominant propagation paths. It was found that the power carried on specular single- and double-bounce reflections from objects in the office (e.g., door frames and whiteboards) are typically 15-20 dB below that carried on the line-of-sight (LOS) path. A further experiment with an absorber phantom (representing the human body) showed the LOS path can be readily shadowed at 60 GHz. However, the attenuation introduced by an internal wall consisting of drywall mounted on timber frames was measured to be between 11-22 dB, leading to the conclusion that internal walls may be insufficient to isolate co-channel systems if the LOS path is otherwise occluded.

17:10 ***Multi-band Indoor Propagation Characterization by Measurements from 6 to 60 GHz***

Diego Dupleich (Ilmenau University of Technology, Germany); Robert Müller and Sergii Skoblikov (TU Ilmenau, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

We introduce simultaneous multi-band ultra wideband directional measurements at 6.75 GHz, 30 GHz, and 60 GHz in an indoor environment with different visibility conditions. Large scale parameters and path-loss has been analysed for the different bands considering the propagation channel, and later the influence of the system aspects in the radio channel. We have observed that the major differences between bands are introduced by the characteristics of the targeted system

17:30 ***Assessment of Drop Size Distributions Obtained by Different Instruments and Their Application to W-Band Propagation Studies***

Santiago Pérez-Peña, Jose M Riera, Ana Benarroch and Marta Munilla-Diez (Universidad Politécnica de Madrid, Spain); Jose Garcia-Rubia (Virginia International University, USA)

The Drop Size Distributions (DSDs) allow the characterization of rainfall phenomena and prediction of rain attenuation. In this paper, long-term measurements from a vertical Doppler radar (MRR-2) and an optical disdrometer are used to obtain and compare the statistics of DSDs in Madrid in periods of at least ten years. The process to obtain the DSDs from the optical disdrometer spectrum is analyzed in detail, providing recommendations about the most appropriate particles filtering. Rain attenuation is calculated from the DSDs obtained from both instruments and the results are compared with rain attenuation time series measured in a W-band horizontal radio link at 75 GHz and 85 GHz.

17:50 ***Indoor Path Loss Measurements at the 5G Millimeter-Wave Bands of 26 and 39 GHz***

Domingo Pimienta-del-Valle, Sergio Hernández-Sáenz, Pedro Saiz Coronado and Luis Mendo (Universidad Politécnica de Madrid, Spain); Pedro Garcia-del-Pino (Universidad Politecnica de Madrid, Spain); Jose M Riera (Universidad Politécnica de Madrid, Spain)

Several millimeter-wave frequency bands have been identified to be used in the 5G wireless communication standard. The use of such high frequencies is one of the pillars of this new technology. Experimental measurements have been taken in the Universidad Politécnica de Madrid at 26 and 39 GHz, two of the bands selected for 5G, and are presented in this paper. Since the propagation campaign in Madrid is at an initial stage, the main equipment characteristics and data processing are presented thoroughly. The measurements were gathered in an indoor hallway scenario with line-of-sight conditions. With them, the propagation loss has been estimated and regression fittings and model comparisons have been carried out with good results.

18:10 ***System Distortion Model for the Cross-Validation of Millimeter-Wave Channel Sounders***

David G. Michelson (University of British Columbia, Canada); Camillo Gentile (NIST, USA); Andreas Molisch (University of Southern California, USA); Jack Chuang and Anuraag Bodi (NIST, USA); Anmol Bhardwaj (University of British Columbia, Canada); Özgür Özdemir, Wahab Ali Gulzar Khawaja and Ismail Güvenç (North Carolina State University, USA); Zihang Cheng (Tsinghua University, P.R. China); Thomas Choi (University of Southern California, USA); Robert Müller (TU Ilmenau, Germany)

Because millimeter-wave directional channel measurements are time-consuming and expensive to collect, there is considerable interest in combining measurement data obtained with different channel sounders in order to yield more comprehensive datasets. The simplest way to verify that the results obtained with these different instruments in a given environment are comparable would be to transport the channel sounders to that environment, collect and process measurement data, and then compare the results. Because this is rarely feasible, we propose an alternative method that is much more practical. It involves: 1) Generating an ideal three-dimensional channel impulse response that corresponds to a scenario of interest, 2) Degrading the ideal response by applying a distortion model that capture the factors that limit the spatio-temporal resolution and dynamic range of each channel sounder, and 3) Applying the multipath component (MPC) extraction techniques used by the channel sounder to the distorted response. After the last step, one will observe: a) correctly estimated, b) incorrectly estimated, c) missing, and d) spurious MPCs. Discrepancies between the ideal and distorted responses will be readily apparent and the performance of the channel sounders can be easily compared in a given environment. The effort required to fully characterize the three-dimensional patterns of the transmitting and receiving antennas is considerable and further work is required to determine the corresponding accuracy requirements.

MT_A02 Ant Theory 2: MT_A02 Antenna Theory 2

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Methods & Tools / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Andrzej A. Kucharski (Wroclaw University of Technology, Poland), Guilherme S. Rosa (Pontifical Catholic University of Rio de Janeiro, PUC-Rio, Brazil)

16:50 ***Geometric Algebra Formulation of the Calderon Projector***

Hector Lopez-Menchon (Universitat Politecnica de Catalunya (BarcelonaTECH), Spain); Juan M. Rius (Universitat Politècnica de Catalunya, Spain); Eduard Ubeda (Universitat Politècnica de Catalunya (UPC), Spain); Alexander Heldring (Polytechnical University of Catalunya, Spain)

Geometric Algebra provides a mathematical frame- work that allows to express many equations of physics in a more compact way. It unifies the electric and the magnetic field in a single mathematical object: a multivector. Then, the four Maxwell's equations can be written as a single one. Here we study how the integral formulation of the electromagnetic field in Geometric Algebra naturally embeds the Calderon Projector when the field is evaluated in a surface.

17:10 ***Analysis of Transient Electromagnetic Field Propagation in Well-Logging Environments via an Efficient Mode-Matching Technique***

Guilherme S. Rosa (Pontifical Catholic University of Rio de Janeiro, PUC-Rio, Brazil); Jose R Bergmann (PUC-Rio, Brazil); Fernando Teixeira (The Ohio State University, USA)

In this paper, we present a study on the response of well-logging sensors exploiting transient electromagnetic sources in complex subsurface formations by using a combined frequency-domain mode-matching technique with a numerical inverse Fourier transform in a computationally efficient manner. We present five representative examples to validate and explore the time evolution of the received waves in view of it velocity and attenuation. Preliminary conclusions are presented and the potential of this approach for the study of the time-domain response of logging-while-drilling sensors in realistic problems with radial and axial stratifications is then summarized.

17:30 ***Perfect Electric Conductor Implementation in 3D Lebedev FDTD***

Farzad Bordbar and Mike Potter (University of Calgary, Canada); Michal Okoniewski (University of Calgary & Acceleware Ltd, Canada)

In modeling of anisotropic materials, the Lebedev grid is an alternative method to regular Yee grid with collocated field components. This complicates handling Perfect Electric Conductor (PEC) interfaces because normal field components need to be accounted for. In this paper, the implementation of 3D PEC boundaries such as outside edges is presented. The accuracy of the method is verified by simulating a ridged resonator filled with an anisotropic material.

17:50 ***A GO/FO Tool for Analyzing Quasi-Optical Systems in Reception***

Huasheng Zhang, Shahab Oddin Dabironezare, Giorgio Carluccio, Andrea Neto and Nuria LLombart (Delft University of Technology, The Netherlands)

In this work, a graphical user interface (GUI) is presented to analyze Quasi-Optical (QO) systems in reception and their coupling to antenna elements. This goal is achieved by using Fourier Optics (FO) and Geometrical Optics (GO) based methods. Specifically, the FO method represents the field focalized by a QO component on its focal plane as a Plane Wave Spectrum (PWS) when the component is illuminated by an incident field. This PWS is related to the field scattered by the QO component which is calculated here using a GO method. By using this spectral representation of the scattered field, the tool estimates the power received by an antenna placed at the focal plane of the QO component. By obtaining this received power, the performance of the antenna-

coupled QO system in reception can be evaluated. In addition, the proposed tool is validated by using full-wave simulation software.

18:10 ***Modal Characteristics of Plasmonic Transmission Lines in Multi-Layered Media Using the Method of Moments***

Mai Sallam (The American University in Cairo & Katholieke Universteit Leuven, Egypt); Guy Vandenbosch (Katholieke Universiteit Leuven (KU Leuven), Belgium); Georges Gielen (KU Leuven, Belgium); Ezzeldin Soliman (The American University in Cairo, Egypt)

This paper presents an integral equation formulation used to obtain the mode characteristics of plasmonic transmission lines. These lines can have any topology and are generally located in multi-layered structure of metallic or dielectric layers. The developed solver calculates the attenuation and phase constants of the lines using the method of moments technique which is characterized by its accuracy and high speed compared to other numerical techniques. The solver also calculates the current components inside the metallic strips constructing the transmission lines. The solver is examined on a number of transmission lines to ensure its accuracy. The obtained results agree very well with the commercial software CST.

L_P01 Loc & Ranging: L_P01 Localization & Ranging

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Localization & Connected Objects / Regular Session / Propagation

Room: Oral Sessions: S4-C - Kielce

Chairs: Krzysztof K. Cwalina (Gdansk University of Technology, Poland), Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

16:50 ***Comparison Between Opportunistic Measurement and Nominal Link Budget for Aeronautical Surveillance Signal***

Junichi Naganawa and Hiromi Miyazaki (Electronic Navigation Research Institute, Japan)

Automatic Dependent Surveillance - Broadcast (ADS-B) is one of the next generation aeronautical surveillance systems for air traffic control. ADS-B requires aircraft to periodically broadcast own position to other aircraft and ground stations, thereby enabling more accurate and frequent surveillance. In this paper, the received signal strength of ADS-B signal is measured and analyzed for opportunistic flights with a focus on the link budget. The measurements are compared with predictions based on the link budget model in the international standards of International Civil Aviation Organization (ICAO). Because the model involves some nominal parameters, differences between the measurements and predictions appear. The bias in the differences is evaluated and statistically characterized for 167 arrival aircraft. Since all the aircraft has a positive bias except for one outlier aircraft, the result verifies that the prediction method is effective for coverage design. Also, another interpretation of the result is given as the accuracy of path loss estimation from received signal strength measurement.

17:10 ***Periodic LoRa Signal Fluctuations in Urban and Suburban Environments***

Thomas Ameloot (Ghent University - imec, Belgium); Patrick Van Torre and Hendrik Rogier (Ghent University, Belgium)

In the interest of deploying large-scale, low-power wireless sensor networks, both theoretical and practical research on the performance of sub-GHz communication technologies is being conducted all over the world. This contribution presents the performance analysis of four LoRa links in an urban/suburban environment. During this study, unexpected, periodic drops in received power levels were found for a 10.6 km, 434 MHz suburban link. These fluctuations are enlarged and comprehensively discussed. They are found to be a propagation phenomenon, most probably related to daily changes in the composition of the troposphere.

17:30 ***Empirical Indoor Propagation Models for LoRa Radio Link in an Office Environment***

Silvano Bertoldo, Miryam Elizabeth Paredes Quintanilla, Lorenzo Carosso, Marco Allegretti and Patrizia Savi (Politecnico di Torino, Italy)

LoRa (Long Range) is one of the most promising candidate technology for Internet of Things (IoT). It support a high number of communication devices spread across large areas. In this paper, we present some indoor measurements performed in a standard office environment using LoRa links. The aims of the work is to assess the indoor propagation performance of LoRa technology and to indicate the best model to be used for a preliminary design of a LoRa based radio link in an office environment. The measured data highlight that LoRa technology can be used in office environment to realize a wireless sensor network. Five commonly used propagation models were also analyzed and their results compared with the measurements. This analysis highlighted that the Motley-Keenan's is the best model to describe indoor propagation.

17:50 ***Large Scale Channel Parameters in Industrial Environment***

Jessen Narrainen (CEA LETI & Université Grenoble-Alpes, France); Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

This paper presents the channel characterization in an industrial environment in a bandwidth covering 2 GHz to 6 GHz. Measurements were performed with a VNA, with virtual arrays used at both the transmitting and receiving side. Characterization of the path loss, delay and angular spreads are presented for three considered propagating conditions: LOS, OLOS and NLOS. Furthermore, the angular spread statistics of clusters are determined.

18:10 ***HAPEE, a Prediction Model of Ionospheric Scintillation in Polar Region***

Vincent Fabbro (ONERA, France); Knut Stanley Jacobsen (NMA, Norway); Sebastien Rougerie (CNES, France)

The main objective of this study is to propose a forecasting model of scintillation indices for the polar region. A first proposition has been done in previous EUCAP publication (2014), with a simple empirical model driven by the Kp geomagnetic index, and where the main output was the instantaneous mean ROTI value. Here, an updated model is proposed, where the main inputs are the solar wind parameters pressure p and Bz (the z component of the Earth magnetic field). A distribution of predicted ROTI (5 minutes or 1 hour prediction) or σφ index is provided instead of a mean value. Thus, the model allows estimating the percentage of time of occurrence for a level of ROTI (or σφ) to be exceeded in the next 5 minutes or 1 hour, or the exceeded ROTI (or σφ) for a corresponding percentage of time.

F_P05 Imaging: F_P05 Imaging and inverse scattering

TOP

Future Applications / Regular Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Dominique Lesselier (L2S UMR 8506 (CNRS - Supélec - Université paris Sud 11), France), Sergei P. Skobelev (Radiophyzika, Russia)

16:50 ***Diagnostic Within a Dielectric Micro-Structure Time-Reversal and Sparsity-Constrained Imaging***

Peipei Ran, Zicheng Liu and Dominique Lesselier (Laboratoire des Signaux et Systèmes, France); Mohammed Serhir (GeePs, CentraleSupelec, France)

Computational imaging of micro-structured systems as a grid-like set of a finite number of circular cylindrical dielectric rods is considered. How to achieve meaningful localization, resolution-enhanced or, even, super-resolved, vs. the wavelength(s) of operation if defects or radiators are to be found within is discussed here. That is, the set can be seen from all around when either a line source inside an intact system of rods is to be localized, or when, now illuminated by exterior line sources, there is an unknown distribution of missing rods. One-shot time-reversal (mostly reduced as time-harmonic back-propagation, though cases involving broadband transient data will be proposed in the presentation) and iterative sparsity-constrained joint source imaging are analyzed as solution tools in both TE and TM polarizations.

17:10 ***UWB Device for Microwave Imaging: Validation Through Phantoms***

Alessandro Vispa (UBT - Umbria Bioengineering Technologies, Perugia, Italy); Lorenzo Sani (UBT - Umbria Bioengineering Technologies, Perugia, United Kingdom (Great Britain)); Martina Paoli and Alessandra Bigotti (UBT - Umbria Bioengineering Technologies, Perugia, Italy); Giovanni Raspa and Navid Ghavami (UBT – Umbria Bioengineering Technologies, Italy); Mohammad Ghavami (London South Bank University, United Kingdom (Great Britain)); Gianluigi Tiberi (London South Bank University, United Kingdom (Great Britain) & UBT - Umbria Bioengineering Technologies, Italy)

Breast cancer detection is still a challenging subject, and this has forced physical, chemical and engineering research to explore new detection modalities. In this context, microwave imaging has received increasing attention in the last decades. Such effort has been encouraged by the fact that, at microwave frequencies, it is possible to distinguish between tissues with different dielectric constant values. In such framework an innovative microwave instrument, is presented here. The apparatus, consisting of 2 antennas operating in air, is completely safe and non-invasive since it does not emit any ionizing radiation and it does not require any breast crushing. We use Huygens Principle to provide fresh understanding into breast cancer detection. The algorithm based on this principle provides inhomogeneity maps of the dielectric properties (dielectric constant and/or conductivity) of different tissues, highlighting their contrast in the resulting final image. The experimental results on phantoms with different dielectric constants and inclusions are presented here. Moreover, on the basis of this analysis, we establish a modality to detect the presence of inclusions inside phantoms.

17:30 ***Lightweight Low-Cost UAV Radar Terrain Mapping***

Eric Ye (University of Waterloo, Canada); George Shaker (University of Waterloo & Spark Tech Labs, Canada); William Melek (University of Waterloo, Canada)

Aerial 3D scene mapping can be done using vision-based methods where many 2D images are combined to create 3D maps. However, these methods have certain disadvantages, especially in scenarios where there is limited or inconsistent lighting, few image features, or fast motion. The low cost and wide availability of automotive 77 GHz allow it to be used in conjunction with unmanned aerial vehicles to achieve terrain mapping with Synthetic Aperture Radar (SAR) techniques. We investigate the feasibility of using such a radar to complement or replace maps generated from vision-based methods. This technique is tested outdoors on a drone flight with real targets.

17:50 ***A Combined Algorithm for High Resolution Microwave Breast Imaging Using Eigenfunction-based Prior***

Nasim Abdollahi, Joe LoVetri and Ian Jeffrey (University of Manitoba, Canada)

A new algorithm for quantitative microwave breast imaging and cancer detection is presented that is based on creating prior information for the finite element contrast source inversion using a non-iterative eigenfunction-based technique. The prior information is introduced as a numerical inhomogeneous background that modifies the contrast and contrast sources variables being inverted by the finite element contrast source inversion. It is found that this type of specialized physics-based prior, that uses the eigenfunctions of the Helmholtz operator, ensures the stability of the subsequent contrast source inversion and produces high-accuracy and high-resolution breast images. The performance of the combined algorithm is verified by simulation studies of a 2D MRI-derived anthropomorphic breast model.

18:10 ***Comparative Features of Cylindrical Electromagnetic Black Holes with Positive and Negative Refractive Indexes***

Sergei P. Skobelev (Radiophyzika, Russia); Yana Chizhevskaya (Moscow Institute of Physics and Technology, Russia)

A problem of plane wave scattering by cylindrical electromagnetic black holes with radial profile of relative permittivity and permeability in the form eps(r)=myu(r)~1/r^2 is considered. The problem is solved both analytically for a basic model of the hole and numerically with use of the one-dimensional finite element method for a modified model. It is shown that the absorption efficiency for the cylinder with a negative refractive index at realistic parameters of losses only insignificantly exceeds the absorption efficiency for the similar cylinder with a positive refractive index in comparison with the case of extremely low losses at the outer surface and extremely high losses at the cylinder axis considered in the previous publications.

H_A08 Metamat: H_A08 Metamaterials, metasurfaces and EBG for antennas

TOP

High Data-rate Transfer / Regular Session / Antennas

Room: Oral Sessions: G1- Gniezno

Chairs: Stefano Maci (University of Siena, Italy), Enrica Martini (Wave Up Srl, Italy)

16:50 ***A 40dBi-Gain Flat Metasurface Antenna***

Gabriele Minatti (Wave Up S. r. l. & University of Siena, Italy); Francesco Caminita (Wave-Up SRL, Italy); Enrica Martini (Wave Up Srl, Italy); Cristian Della Giovampaola (Wave Up srl, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Fabrizio De Paolis (ESA, Italy); Stefano Maci (University of Siena, Italy)

Metasurfaces have been successfully applied to design very high gain flat antennas for VSAT communications in the Ka band. The antennas consist of printed grounded dielectric slabs fed at the center by a coaxial connector. Antennas for both the transmitting and the receiving band have been designed, fabricated and tested. For the first time for this kind of technology, a measured gain as high as 39.5 dBi has been measured at 30 GHz.

17:10 ***Design of a Groove Gap Waveguide to Microstrip Inline Transition***

Jose M. Perez (Universidad Publica de Navarra, Spain); Alicia E. Torres-García and Ramon Gonzalo (Public University of Navarra, Spain); Iñigo Ederra (Universidad Pública de Navarra, Spain)

In this paper the design of an inline transition between microstrip and groove gap waveguide operating at W-band is presented. The transition consists of two sections: a tapered microstrip line and a Chebyshev transformer. The simplicity of this design makes this transition appropriate for MMIC packaging at millimeter frequencies and above. Experimental validation has been carried out in the W-band. Good performance has been achieved: return loss better than 10 dB and mean insertion loss lower than 2 dB.

17:30 ***Design of Substrate Integrated Waveguides Supporting Degenerate Band-Edge Resonances***

Tianyu Zheng (Sorbonne University, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France); Ahmed F. Abdelshafy and Filippo Capolino (University of California, Irvine, USA); Zhuoxiang Ren and Guido Valerio (Sorbonne Université, France)

A degenerate band edge is a resonant dispersive behavior of coupled transmission lines arising from a fourth-order degeneracy due to the coalescence of two propagating and two evanescent modes. It leads to a so-called giant resonance resulting in field enhancement inside the transmission line. In this paper, we propose a SIW periodic line supporting a degenerate band edge and we study the impact of losses. Conductor and dielectric losses are analyzed in the full-wave simulations of the unit cell and of truncated structures.

17:50 ***Millimeter-wave Huygens' Metasurfaces Based on All-dielectric Resonators for Antenna Beam-forming***

Shulabh Gupta (Carleton University, Canada); Takashi Tomura and Soichi Sakurai (Tokyo Institute of Technology, Japan); Daniel King (Carleton University, Canada); Jiro Hirokawa (Tokyo Institute of Technology, Japan)

A novel mm-wave all-dielectric structure based on Huygens' metasurfaces is proposed to engineer the radiation fields of a 2D slot array antenna, and demonstrated using full-wave simulations. The proposed metasurface consists of elliptically-shaped resonators whose geometrical dimensions can be engineered to enable rich wave transformation capabilities. They are placed on top of the slot antenna array in its near-field zone and designed to transform the intrinsic uniform field distribution of the antenna to desired radiation patterns. A beam tilting example has been presented to demonstrate the proposed principle.

18:10 ***Dual Broadband Coplanar Waveguide-Fed Slot Antenna for 5G Applications***

Asmaa Ibrahim Afifi (EJUST, Egypt); Dalia Elsheakh, dalia (Electronics Research Institute & ElTahrir St. Dokki Giza, Egypt); Adel B. Abdel-Rahman (EJUST, Egypt); Ahmed Sayed Ahmed Abdelhamid Allam (Egypt-Japan University of Science and Technology (E-JUST), Egypt); Sabah Ahmed (Egypt-Japan University of Science and Technology, Egypt)

In this paper a dual broadband CPW-Fed slot antenna is presented for 5G applications. This antenna operates at the lower and the millimeter (mm) wave bands, especially the 28/38 GHz of the mm-wave bands of the 5G wireless communications. The proposed antenna is compact with a size of 20 × 15 mm2. It has two bands which are extended from around 3.4 to 7.3 GHz and upper band extended from 20 to 38 GHz. These bands are achieved by using a rectangular slot with a triangle strip, two shunt stubs and a rectangular patch inside the slot. The results show that this antenna has impedance bandwidth of 80% and 66.6% for the lower and upper bands respectively. CST Electromagnetic simulator is used to simulate the proposed antenna which it provides omni-directional pattern and good gain over the operating two bands.

S_A26 3D Print Ant: S_A26 3D-printed antenna technologies

TOP

Space / Regular Session / Antennas

Room: Oral Sessions: G2- Opole

Chairs: Shengjian Jammy Chen (The University of Adelaide, Australia), Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

16:50 ***Additive Manufactured Three Dimensional Luneburg Lens for Satellite Communications***

Oskar Dahlberg (KTH Royal Institute of Technology, Sweden); Oskar Björkqvist (KTH Royal Insitute of Technology, Sweden); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

A method for designing gradient refractive index (GRIN) lenses with additive manufacturing or 3D-printing at K_u band is presented. To demonstrate the potential of the method, we designed a Luneburg lens using a single low-loss dielectric material available for 3D-printers. The gradient index is realized by varying the local material fill density of the lens. We demonstrate with full wave simulations that the structure is able to transform a spherical electromagnetic wave to a plane wave. When the lens is fed with a rectangular waveguide, the overall antenna has a gain of 23 dBi with side lobe levels of -12.5 dB in K_u band. This lens, when integrated with a circular polarized feeding system, could find application for ground satellite communications.

17:10 ***Sidelobe Level Reduction in Ridged Leaky Waveguide Through Stereolithography***

Aurélie Dorlé (Institut d'Électronique et de Télécommunications de Rennes UMR CNRS 6164, France); Raphael Gillard (IETR & INSA, France); Esteban Menargues (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland); Maarten van der Vorst (European Space Agency, The Netherlands); Emile de Rijk (SWISSto12 SA, Switzerland); Petronilo Martin-Iglesias (European Space Agency, The Netherlands); María García-Vigueras (IETR-INSA Rennes, France)

This article presents a single-polarized directive leaky-wave antenna at Ka-band providing low sidelobe level. The considered structure is original and consists in a slotted and ridged waveguide, which is excited by a single mode through a rectangular-to-square transition. By properly modulating the length of the slots and the height of the ridge along the antenna, it is possible to achieve full control over the complex illumination. The additive manufacturing process of stereolithography is used to print the low sidelobe level prototype. Measurements are presented and show nice agreement with full-wave simulations, reaching a sidelobe level of - 15.3 dB at 30 GHz.

17:30 ***Additively Manufactured Triple-Band Fractal Antenna-on-Package for Ambient RF Energy Harvesting***

Azamat Bakytbekov and Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

Billions of wireless sensing devices must be powered for the Internet of Things (IoT) applications. Collecting energy from ambient RF spectrum to power sensor nodes is one of the possible solutions. In this work, we present an antenna for RF energy harvesting applications which operates at multiple bands and has been realized through additive manufacturing (combination of 3D and screen printing) on a package, thus optimizing the space and cost requirements. The antenna design utilizes the cantor fractal approach which enables it to operate at three frequencies (GSM900, GSM1800 and 3G at 2100MHz) simultaneously. Decent gain, triple-band performance, lower cost and compact size makes this antenna a promising candidate for ambient RF energy

harvesting applications.

17:50 ***Conformal Space-Filling Electromagnetic Skins for the Wireless Monitoring of 3D Object Integrity***

Simone Nappi (University of Rome Tor Vergata & Radio6ense srl, Italy); Pier Paolo Valentini (University of Roma Tor Vergata, Italy); Gaetano Marrocco (University of Rome Tor Vergata, Italy)

The use of polymer-based objects in a wide range of applications requires a regular monitoring of their health status in order to prevent potential failures during service. The exposure of these objects to mechanical or chemical stressing agents may accelerate their natural aging process. A non-invasive and early monitoring of these aging signs may enable a predictive maintenance in order to avoid, or at least to minimize, unexpected failures. This paper describes a wireless crack detection method based on space-filling curves working like an electromagnetic second-skin enveloping the object. The conformal sensor permits to remotely transmit the presence of small defects over the object by using Radio Frequency Identification. The proposed idea is corroborated by numerical modeling and by experimentations with a plastic pipe joint coated by a three-cells sensing skin made by silver conductive paint that is suitable to enable a wireless crack detection system up to 1.5m distance.

18:10 ***Ku-Band SFB-Cluster Manufactured by Additive Manufacturing Techniques***

Michael Kilian, Andreas Schinagl-Weiß and Alexander Sommer (Airbus Defence and Space GmbH, Germany); Christian Hartwanger and Michael Schneider (Airbus, Germany)

This paper investigates the use of novel manufacturing techniques for high throughput satellites. An entire feed cluster including waveguide runs was developed regarding design rules for novel additive layer manufacturing to use that cluster for prospectively upcoming applications with increased needs for frequency re-use factors like inflight connectivity. Based on strong experience in antenna design and the additive manufacturing process, a tradeoff between RF performance and mechanical parameters was made to get a low mass component with sufficient accuracy and RF performance.

B_A02 Imag Sensing: B_A02 Imaging, Sensing, and Radar Antennas

TOP

Biomedical / Regular Session / Antennas

Room: Oral Sessions: A2- Ustka

Chairs: Declan O'Loughlin (National University of Ireland Galway, Ireland), Kuwahara Yoshihiko (Shizuoka University, Japan)

16:50 ***Microwave Mammography Enabling Pathological Diagnosis***

Kuwahara Yoshihiko, Yuhji Nakada and Akira Nozaki (Shizuoka University, Japan); Kimihito Fujii (Aichi Medical University, Japan)

Because the microwave tomography which solves the inverse scattering problem, reconstructs a tomographic image of the electric constant distribution of an object, it is expected to be applicable to an apparatus used for pathological diagnosis. We measured and analyzed the complex permittivity of breast tissue surgically removed from a breast cancer patient. It was found that the conductivity distribution of the cancer tissue is separated from the distribution of other tissues when expressed based on parameters of the Debye model instead of the frequency-dependent complex permittivity. The distribution of the Debye model parameters in the breast can be estimated by solving the inverse scattering problem. Herein, we show that it is possible to identify cancerous areas through a computer simulation.

17:10 ***Advantages and Disadvantages of Parameter Search Algorithms for Permittivity Estimation for Microwave Breast Imaging***

Declan O'Loughlin (National University of Ireland Galway, Ireland); Bárbara L. Oliveira, Martin Glavin, Edward Jones and Martin O'Halloran (National University of Ireland, Galway, Ireland)

Multiple clinical investigations of radar-based breast imaging devices have been demonstrated in recent years, including two competing commercial systems which are currently being tested in clinics. Expected enrollment using MARIA is expected to be 994 and will include women with both dense and non-dense breasts which can have different average dielectric properties. Numerous studies have shown that the normal variance in the dielectric properties of the breast between women can impact both the image quality and the expected sensitivity which can be achieved using radar-based breast imaging. This paper examines the potential to use parameter search algorithms to improve the sensitivity of radar-based breast imaging. Although these parameter search algorithms have been shown to improve image quality in a limited number of test cases, this is the first analysis of the potential impact of realistic dielectric properties estimation on the sensitivity of radar-based imaging.

17:30 ***Design of a Millimeter-Wave Near-Field Probe for Early-Stage Skin Cancer Detection***

Giulia Mansutti (Università degli Studi di Padova, Italy); Ahmed Toaha Mobashsher (The University of Queensland & LicenSys Pty Ltd, Australia); Amin Abbosh (The University of Queensland, Australia)

This work presents the design of a practical and low-cost near-field probe for early-stage skin cancer detection. The device utilizes substrate integrated waveguide (SIW) technology to ensure an easy and cheap fabrication process. Moreover, the adoption of a high dielectric constant substrate material provides a good match with the skin. This in turn allows to use the probe in direct contact with the investigated area, making it a practical and effective tool for scanning a suspected body area in an in-vivo scenario. The tip of the device, i.e., the part that is in direct contact with the skin, is capable of concentrating the electric field on a small region thanks to a tapered design, and in this way a sub-millimeter lateral resolution of 0.2 mm can be achieved. The probe is designed to operate between 35 and 45GHz, and to achieve a penetration depth of 0.4 mm in order to detect small cancer lumps. The device operates according to a differential approach, i.e., it senses relative changes in the dielectric properties of a suspect area with respect to its healthy surroundings. In this way, the effectiveness of the probe is granted for all the individuals and body regions, and regardless of the hydration level or thickness of the skin. The design has been realized and tested through full-wave numerical simulations in CST Microwave Studio.

17:50 ***Study of Penetration Ratio Using UWB Antenna with an in Vivo Subject***

Hamza Benchakroun (iTeam, Universitat Poltècnica de València & Information Technology and Modeling Laboratory, National School of Applied Sciences, Cadi Ayyad University, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Bataller and Sergio Castelló-Palacios (Universitat Politècnica de València, Spain)

This paper presents a study of the penetration ratio through the human tissue for Body Area Network (BAN) applications of a compact antenna with directive behavior and wide impedance matching. The antenna is a coplanar UWB monopole covering the band from 2.8 GHz to 13.8 GHz. To analyze the penetration ratio of the antenna, two experiments using a phantom and an in vivo subject have been carried out. According to the experiments and the measured results, the antenna with enhanced radiation pattern and wide impedance matching, leads to a very good penetration into the human tissue. Measurements have been performed to demonstrate the validity of the simulated antenna performance through two experiments. The optimized UWB antenna displays a penetration ratio up to 17 cm in pure fat phantom and up to 16 cm in an in vivo subject, combined with a matching band of more than 10 GHz.

18:10 ***Design of A Compact Ultra-Wideband Antenna for Super-Wideband Technology***

Majed Dwairi and Amjad Hendi (Faculty of Engineering Technology Al-Balqa Applea University, Jordan); Mohamed S. Soliman (Taif University, Saudi Arabia); Mahdi Nisirat (Albalqa'a Applied University, Jordan)

This paper presents a monopole ultra-wideband (UWB) patch antenna with enhanced bandwidth performance for super-wideband applications. The reference antenna has a modified circular radiator consists of a circular patch integrated with two circular shapes at 5mm from the main patch center with radius of 5.35mm. The modified patch is mounted on a FR4-epoxy substrate with a relative permittivity of 4.4 and a dielectric tangent loss of 0.024 and fed by a microstrip feed line of 50 Ω characteristic impedance. The other side of the substrate has a partial ground plane. Parametric study is done to estimate the proper dimensions of the proposed antenna. Four different slot configurations: rectangular, circular, torus, and a drinking cup shape, with proper dimensions have been inserted to the partial ground plane under the feed line to modify the reference antenna bandwidth characteristics. The simulation results using CST-EM software package prove that the antenna fractional bandwidth of the reference antenna is 129.9% while for the four different antenna models are changing from 160.6% to 167.45%, that means that the proposed antennas bandwidth increases from 31.7% to 37.55%. The antenna maximum gain, directivity and far field radiation pattern also investigated.

Friday, April 5

Friday, April 5 8:40 - 10:20

Sp_A03 Refl, Feed, Comp for Space: Sp_A03 Reflector, Feed Systems, and Components for Space Application

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Space / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia), Donia Oueslati (ICTEAM Institute, Université Catholique de Louvain, Belgium)

8:40 ***Large Deployable Spaceborne Reflector Antennas in Europe: Progress Status and Perspectives***

Jean-Christophe Angevain (ESA, The Netherlands); Alexander Ihle and Gonçalo Rodrigues (European Space Agency, The Netherlands); Julian Santiago-Prowald (European Space Agency (ESTEC), The Netherlands)

Due to the limited volume available under the launcher fairing, large spaceborne reflector antennas need to have their RF radiating aperture unfurled once the satellite is placed on its orbit. This is the case for reflector antennas with aperture diameters above 3-4 meters for conventional geostationary satellites but it may also apply to reflectors with smaller diameter when embarked on a small or micro satellite. The need for larger radiating apertures is mainly driven by increased gain and/or higher resolution and sensitivity required by the advanced satellite telecommunication payloads or microwave instruments for Earth Observation and Science missions. It is proposed in this paper to provide the current progress status of large deployable spaceborne reflector antennas in Europe in terms of research and development. Future outlooks in Europe regarding this technology are then presented.

9:00 ***Design of a Hybrid Linear-Array Fed Doubly Curved Reflector Antenna with a Hexagonal Beam Lattice***

Nelson Fonseca (European Space Agency, The Netherlands); Etienne Girard (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France)

In this paper, a design procedure to generate a hexagonal beam lattice from a linear-array fed doubly curved reflector antenna is described. When all linear arrays are identical, this reflector antenna configuration naturally generates a square lattice of beams, which is not optimal as a multiple spot-beam coverage for communication satellites. By an adequate adjustment of its design parameters, it is possible to obtain the desired hexagonal beam lattice while maintaining all the advantages of the proposed antenna configuration, mainly its feed system simplicity when compared to alternative imaging reflector configurations. The proposed design procedure is illustrated through a specific numerical example at Ka-band.

9:20 ***Performance Aspects of Large-Deployable Reflector Antennas Based on Surface Deformations Simulated for Tandem-L***

Patrick T.P. Klenk, Jens Reimann and Marco Schwerdt (German Aerospace Center (DLR), Germany)

Based upon the needs of the scientific community, the next generation of Earth observation synthetic aperture radar satellites will focus on comparatively longer wavelengths such as L- or even P-band. Due to operational constraints, instruments currently under development will likely be constructed as a phased array antenna feed paired with a large deployable reflector (LDR) / boom assembly. Compared to traditional planar antenna array based instrument designs, this leads to a series of novel challenges which have to be addressed. In this presentation we discuss several LDR performance aspects related to SAR-based Earth observation from low Earth orbits. Based upon the present reference scenario for Tandem-L, a current proposal for a future high performance SAR mission, we find that expected intra-orbit thermo-elastic deformations should have a tolerable impact on the SAR signal after digital beamforming in terms of gain and phase variations. Furthermore, the potential for reflector shaping opens a trade space which has to be carefully assessed.

9:40 ***Uncertainty Quantification for Modern Antenna Systems***

Oscar Borries, Erik Jørgensen, Min Zhou and Jakob Rosenkrantz de Lasson (TICRA, Denmark)

Many modern antenna systems, particularly for applications in telecommunication or earth observation, have significant mechanical complexity. This entails an often lengthy and detailed design process, where the design is carefully revised to ensure the best performance for the intended application. In particular, the electrical design often needs to take into account uncertainties in the mechanical design. In this paper, we present an efficient way of quantifying the effects of uncertainties by using electromagnetic simulation of the antenna design with mechanical uncertainties added to the model of the antenna. The methods shown here far outperform the conventional Monte-Carlo techniques, both in terms of accuracy and computational time.

10:00 ***Application of the Riemann-Silberstein Vectors and Source Matching Method to a Beam-Waveguide Vector Field Analysis***

Igor Belkovich and Boris Kogan (National Research University Moscow Power Engineering Institute, Russia)

In antenna theory, there is traditionally a problem of rigorous vector analysis of the electromagnetic field in electrically large antennas. Such an analysis is always time-consuming and requires significant computational resources, or done with the use of approximation methods. In this paper, theoretical foundations and techniques of solving such problems utilizing the Riemann-Silberstein vectors (RS vectors) and the method of rigorous analytical solution of Maxwell's equations - spherical wave expansion are presented. In homogeneous space, the two RS vectors describe vector fields of ideal circular polarization (RHCP and LHCP) and propagate independently. The vector spherical expansion technique in terms of the RS vectors is developed using the helical coordinate system and the generalized spherical harmonics. The expansion is symmetrical and has a simpler mathematical description compared to the classical multipole expansion. A method of expansion coefficients definition directly from a source current distribution is developed, which allows to simplify field calculation in reflector antenna systems. The purpose of this paper is to show advantages of the RS vectors utilization and to present efficient algorithms of the accurate electromagnetic field analysis for applied electromagnetics problems.

F_A04 Theory for Future Apps: F_A04 Antenna Theory for Future Applications

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Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Andrea Neto (Delft University of Technology, The Netherlands), Jorge A. Tobon Vasquez (Politecnico di Torino, Italy)

8:40 ***Acceleration of Finite Periodic Structures Analysis Through Matrix Compression Techniques***

Alberto Serna (University of Extremadura, Spain); Jorge A. Tobon Vasquez and Javier Rivero (Politecnico di Torino, Italy); Luis Landesa (University of Extremadura, Spain); Francesca Vipiana (Politecnico di Torino, Italy)

Slotting the impedance matrix to perform the matrix-vector product through the use of FFT, procedures named slotFFT techniques, is an efficient way to accelerate the solution of electromagnetic analysis of finite periodic structures through the SIE-MoM framework. This work presents the combination of a slotFFT technique with two different matrix compression methods, one based on full domain power-decoupled macrobasis, and other based on skeletons to increase the achieved acceleration, showing the versatility of the proposed slotFFT algorithm to be integrated with different frameworks.

9:00 ***The Observable Field for Generalized Incidences***

Arturo Fiorellini Bernardis and Andrea Neto (Delft University of Technology, The Netherlands); Angelo Freni (Università degli studi Firenze, Italy); Nuria LLombart (Delft University of Technology, The Netherlands); Diego Emer (Technische Universiteit Delft, Italy)

The Observable Field is the portion of the incident field that can contribute to the signal received by an antenna. Recently, the Observable Field was estimated for a plane wave incidence. Here, the procedure is extended to a general incident fields expressed as a superposition of multiple plane waves. As a case study we consider a communication scenario which involves a base station and distributed receivers embedded in a complex scattering environment. The Observable Field concept provides clear guidelines for the design of the receiving terminal antennas. In particular, it emerges that to maximize the received power, the pattern in transmission of the antenna should be synthesized to reproduce the angular pattern of the Observable Field. This is specifically relevant in cases of non-line of sight at high frequencies, where the power received can drop by several orders of magnitude.

9:20 ***Equivalent Circuit Models of Finite Slot Antennas***

Ralph van Schelven, Daniele Cavallo and Andrea Neto (Delft University of Technology, The Netherlands)

We propose a systematic approach to describe slot antennas, embedded in generic stratified media. An equivalent transmission line model for the slot is proposed, based on a spectral domain analysis. We introduce a method of moments solution to model semi-infinite or finite slots. The solution entails two basis functions, one at the feed and one at the terminations. The latter basis function is chosen to properly account for the field diffractive behavior at the antenna end points. An approximate circuit model is then introduced, which describes the main mode propagating along the slot as an equivalent transmission line. Lumped impedances are extracted to accurately describe both the reactance of the feed and the termination, and the radiation emerging from these points. This procedure can be used to derive the input impedance of planar antennas with arbitrary length in generic layered media or the interaction between multiple feeds within one slot.

9:40 ***Limitations and Optimization of Supergain End-Fire Arrays***

Alexandre Debard (University of Grenoble Alpes & CEA-LETI, France); Antonio Clemente (CEA-LETI Minatec, France); Christophe Delaveaud (CEA-LETI, France); Patrick Potier ((DGA), France); Pouliguen Philippe (DGA, France)

In this paper, the possibility to optimize supergain end-fire arrays is numerically investigated. Firstly, the optimization problems in terms of directivity and gain are introduced. Then, infinitesimal-dipole based end-fire arrays have been optimized as a function of the number of elements and inter-element spacing. It is shown that, their radiation efficiency can be predicted and, for close inter-element spacing, even optimized to provide a higher gain than the one obtained with the classical directivity optimization methods. The numerical analysis is detailed and validated by full wave simulations in the case of three half-wave dipoles.

10:00 ***A Concept Study of Near-Field Imaging Using Frequency Modulated Continuous Wave Radar***

Arslan Azhar (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

The paper presents a concept for near-field imaging of a scatterering device under test using measurements taken by a Frequency Modulated Continuous Wave (FMCW) radar that has linearly increasing frequency with time. A suitable formulation of a near-field transformation for the monostatic FMCW observations is also discussed. A scattering model based on ideal point scatterers and point observations is used to describe the involved steps. Finally, a numerical example is included to demonstrate the imaging performance.

F_A32 Other topics: F_A32 Other topics

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Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Christophe Delaveaud (CEA-LETI, France), Stephanie Smith (CSIRO & Astronomy and Space Science, Australia)

8:40 ***Study on Miniaturized Super Low frequency(SLF) Transmitting Antenna***

Yunxiao Xu (Shanghai Jiao Tong University, P.R. China); Junping Geng (Shanghai Jiaotong University, P.R. China); Kaijie Zhuang (Shanghai JIao Tong University, P.R. China); Haobo Wu and Jiawei Han (Shanghai Jiao Tong University, P.R. China); Kun Wang (Sahnghai Jiao Tong University, P.R. China); Han Zhou and Ronghong Jin (Shanghai Jiao Tong University, P.R. China); Xianling Liang (Shanghai Jiaotong University, P.R. China); Weiren Zhu (Shanghai Jiao Tong University, P.R. China)

A new type of SLF antenna based on motor rotator is proposed. The size of the antenna is no longer limited by frequency. The antenna consists of a rotating magnetic dipole. The frequency of the signal can be controlled by the rotational speed. In order to facilitate analysis and understanding, the rotating magnetic field generated inside the motor can be equivalent to a rotating magnetic dipole which is a miniaturized SLF antenna. The simulation fields at SLF band are consistent with the theoretical derivation, which also proves that the derivation is correct.

9:00 ***Application of Tensor Decomposition Methods to Antenna Array Calibration Measurements for De-Noising and Narrowband Modelling***

Stephan Häfner (Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

Narrowband modelling of an antenna array's response is often considered for parameter estimation or modelling purposes. Because the narrowband assumption has to be carefully assigned, a new criterion to justify the narrowband assumption based on array calibration data will be presented. Subsequently, tensor decomposition methods are presented, which are applicable to estimate a narrowband array model from array calibration measurements while incorporating various assumptions regarding the calibration measurement system or the antenna array. The performance of the proposed decomposition methods will be compared in Monte-Carlo simulations using synthetic as well as measurement data.

9:20 ***A Method of Reducing Mutual Coupling Using an Extra Coupling Path***

Lei Chen, Tianling Zhang, Sadegh Mansouri Moghaddam, Ashraf Uz Zaman and Jian Yang (Chalmers University of Technology, Sweden)

A method of reducing mutual coupling for a large-scale array with the wideband and beam steering characteristics is proposed in this work. An extra coupling path is intentionally introduced to reduce the mutual coupling among adjacent radiating elements. A millimeter wave array is used to verify the proposed method. The simulation results show that the mutual coupling between adjacent elements can be reduced to below -15 dB over the band of 19-39.5 GHz and this concept is viable even for the beam steering angle range of ±45°.

9:40 ***The Battle for Brown Boveri. Salvaging and Restoration Conception of the SL 61 B3 Long-Wave Transmitter***

Tomasz Aleksander Miś (Warsaw University of Technology & Institute of Radioelectronics and Multimedia Technology, Poland); Sebastian Orda-Sztark (Babice Radio Station Culture Park Association, Poland); Piotr Plachta and Lukasz Ostafin (RCN Konstantynow, Poland)

This article presents the Konstantynów Radio Transmitting Centre - Poland's leading longwave radio broadcasting facility, active between 1974 and 1991 - and its transmitter, the Brown Boveri SL 61 B3. Composed of two parts of 1000 kW each, it is considered one of World's most powerful radio transmitters. Having a five-staged modulator, three-staged high-frequency power circuit, nuclear standard frequency generators, microwave (5.6 GHz) modulation signal acquisition and elaborated automated control system, it presented the leading technology of radio broadcasting in the 2nd half of the XX century. Its high significance, both historic and technological, led to the unprecedented action of moving the entire (!) transmitter from the Centre (seriously dilapidated after the collapse of the World's highest radio mast in 1991 due to errors in renovation) to the Babice Transatlantic Radio Station Culture Park Association with the cooperation with the Warsaw University of Technology and other entities. The transmitter, despite the damages caused by devastations and thefts, shall be renovated as a functioning historic equipment with the possibilities of its use for research purposes.

10:00 ***Additive Manufacturing of Waveguide Polarizer for K-band Feed System***

Stephanie Smith (CSIRO & Astronomy and Space Science, Australia); Ken Smart and Nick Carter (CSIRO Astronomy and Space Science, Australia); Nasiha Nikolic and Andrew Weily (Antenna Engineer, Australia); Ivan Kekic (Mechanical Engineer, Australia)

A compact septum waveguide polarizer designed for additive manufacturing is presented. An electroformed prototype has been manufactured with excellent performance achieved. The reflection coefficient of the 3D printed polarizer is predicted to be less than -30dB from 18 - 21.5GHz and the axial ratio is predicted to be less than 1.1dB over the same range.

C_A01 Array Ant: C_A01 Array antennas, antenna systems and architectures

TOP

Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-A - Poznan

Chairs: Dirk Heberling (RWTH Aachen University, Germany), Anu Lehtovuori (Aalto University, Finland)

8:40 ***Impact of the Elevation Scanning Angle on the Vertical Compliance Distance of 5G Massive MIMO Antennas***

Thomas Kopacz and Dirk Heberling (RWTH Aachen University, Germany)

The evolution of mobile radio networks towards 5G leads to a deployment of massive MIMO antennas which are able to serve spatially separated users with individual beams. For site certification procedures, in Germany for instance, all base station antennas are assumed to radiate with maximum transmit power using a maximum envelope of all possible tilts and scanning angles. For the expected high scanning range in elevation, this might lead to increased vertical compliance distances. This paper evaluates the dominant factor causing the vertical compliance distance and investigates the impact of the beam scanning range for two designs of a massive MIMO antenna. The results show that the vertical compliance distance is caused by the main lobe, as long as a part of it is below the horizon. Compared to the case of no electrical downtilt, a vertical scanning range of ±15° increases the vertical compliance distance up to 161 %.

9:00 ***An Architecture Analysis for Millimeter-Wave Optically Steerable Antenna Array***

Christian Ballesteros and Marcos Maestre (Universitat Politecnica de Catalunya, Spain); Maria C Santos (Universitat Politecnica Catalunya, Spain); Jordi Romeu (Universitat Politècnica de Catalunya, Spain); Luis Jofre (Universitat Politecnica de Catalunya, Spain)

Emerging 5G applications require technological solutions to provide larger data rates through wireless links. In the millimeter-wave frequency region there is a wide unexploited area open to allocate new services. In consequence, there is a growing interest in investigating efficient and innovative designs at those frequencies. New challenges appear due to the additional losses and compact, integrated antennas are required. On the other hand, light is a suitable carrier to overcome some of those problems in a guided environment. Moving all processing and transport of the signals to the optical domain can improve both efficiency and capacity. Therefore, mmWave-photonics is an adequate trade-off. The goal of this paper is the design of a planar antenna as an integrated solution with a highspeed InGaAs PIN photodiode. The received power is improved with a lens-based array structure to increase the gain and steer the radiated beam towards a particular user position.

9:20 ***A Camouflage Antenna Array Integrated with a Street Lamp for 5G Picocell Base Stations***

Ahmed Alieldin, Yi Huang, Manoj Stanley, Sumin David Joseph and Tianyuan Jia (University of Liverpool, United Kingdom (Great Britain)); Fatma Elhouni (The University of Liverpool, United Kingdom (Great Britain)); Qian Xu (Nanjing University of Aeronautics and Astronautics, P.R. China)

This paper proposes a new design of a camouflage dual-polarized antenna for 5G picocell base stations. The antenna covers the frequency band from 3.25 GHz to 3.85 GHz with a good isolation between its ports (≥ 22 dB) and a low profile. The proposed antenna consists of two layers separated by an air gap (a radiating layer and a feeding layer). The radiating layer uses a transparent conducting film (Indium Tin Oxide) to form two patches (a radiating patch and a parasitic patch) printed on the opposite sides of a glass laminate. The radiating patch is meshed to improve the transparency of the antenna. The visual transparency of the radiating layer makes it possible to be integrated with the glass cover of the head of a street lamp while the feeding layer is embedded inside the head for camouflage. A 2 × 2 antenna array is formed to achieve a realized gain of 13.2 dBi and cover a solid angle of 33° × 33° making the proposed design a good candidate for the 5G picocell base stations.

9:40 ***A 2-By-2 Sub-Array for Scalable 28GHz mmWave Phased Array Horn Antenna in 5G Network***

Mark Tan (AAC Technologies PTE LTD, Singapore); Guan Hong NG and Roger Tay (AAC Technologies Pte Ltd, Singapore)

The upcoming 5th Generation (5G) technology in mobile communication has led to many designs of millimeter-Wave (mmWave) Phased Array Antenna that can offer high antenna gain and ability in beamforming at different angles, with the aims to achieve higher data transfer rate and low latency. This paper presents a scalable solution for 28GHz mmWave Phased Array Horn Antenna for applications in the 5G network. The Phased Array Horn Antenna is made up of M x N numbers of smaller unit of 2-By-2 Sub-Array Horn Antenna, arranging in rectangular array layout. Each 2-By-2 Sub-Array Horn Antenna consists of four horn radiating elements in a 2 x 2 matrix layout, along with a Qual-Core Phase-Shifter Integrated Circuit (IC) that is integrated within the antenna structure, to introduce phase difference to the four radiating elements in the Sub-Array Antenna for beam-steering purposes. This paper details the design of the 2-By-2 Sub-Array Horn Antenna along with its simulated antenna performance, as well as the different configurations of Phased Array Horn Antenna and their performance characteristics.

10:00 ***Wide-angle Impedance Matching of Antenna Arrays with Circuit Synthesis and Optimization Tools***

Riku Kormilainen and Anu Lehtovuori (Aalto University, Finland); Jussi Rahola (Optenni Ltd, Finland); Harri Varheenmaa (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

Future 5G wireless communication requires beam steerable antenna arrays. The challenge of these antenna arrays is the changing input impedance as a function of steering angle, which is difficult to compensate with matching networks. We propose a novel method of designing and matching antenna arrays at different steering angles simultaneously with the combined usage of unit cell model and Optenni Lab software aimed for matching circuit synthesis and optimization. We apply the method to a linear patch antenna array. The results show the potential of this approach.

MT_P01 Propag Model: MT_P01 Propagation modelling and simulation

TOP

Methods & Tools / Regular Session / Propagation

Room: Oral Sessions: S4-B - Lublin

Chairs: Tetsuro Imai (NTT DOCOMO, INC., Japan), Krzysztof Nyka (Gdansk University of Technology, Poland)

8:40 ***An Improvement of Global Complex Roots and Poles Finding Algorithm for Propagation and Radiation Problems***

Maciej Jasinski, Sebastian Dziedziewicz, Maria Jozwicka and Piotr Kowalczyk (Gdansk University of Technology, Poland)

An improvement of the recently developed global roots finding algorithm has been proposed. The modification allows to shorten the computational time by reducing the number of function calls. Moreover, both versions of the algorithms (standard and modified) have been tested for numerically defined functions obtained from spectral domain approach and field matching method. The tests have been performed for three simple microwave structures (open waveguides and conformal antenna resonator). The results have been verified and the increase of efficiency for the improved version of the algorithm has been confirmed.

9:00 ***Radio Propagation Prediction Model Using Convolutional Neural Networks by Deep Learning***

Tetsuro Imai, Koshiro Kitao and Minoru Inomata (NTT DOCOMO, INC., Japan)

Recently, advancement of artificial intelligence has been remarkable, and many applied researches are attracting attention now. Most of them are based on deep learning. Here, we have proposed radio propagation prediction model using convolutional neural networks (CNN) by deep learning. This paper explains our proposed model in detail, and clarifies its performance by evaluating behaviors for map-parameters input to CNN.

9:20 ***Physical Identification of Common Clusters for Outdoor Microcells***

Julian Villegas Gutierrez (Université Catholique de Louvain, Belgium); Domingo Pimienta-del-Valle (Universidad Politécnica de Madrid, Spain); Claude Oestges (Université Catholique de Louvain, Belgium)

In geometry-based stochastic models, Interacting Objects (IOs) define scattering obstacles. The identification of groups of waves (clusters) linked to IOs is addressed in this paper, based on measurements conducted in an outdoor microcellular scenario at 3.8GHz.By contrast to the classical approach clustering waves in the parameter space, the proposed approach is able to identify physical IOs. Moreover, a method to define common clusters at different mobile locations is further described.

9:40 ***Limitations of the ITU-R P.838-3 Model for Rain Specific Attenuation***

Eric Regonesi, Lorenzo Luini and Carlo Riva (Politecnico di Milano, Italy)

The International Telecommunication Union (ITU) recommendation P.838-3 provides a method to calculate the specific attenuation due to rain. Although the model nature is twofold, to hold a physical basis and to maximize the accordance with experimental data, its current implementation comes with some limitations and inaccuracies. In this contribution we highlight some differences observed when a physically based attenuation model is built and used for comparison. Some nonphysical behaviors of the ITU model are spotted with the variation of rain rate, polarization and elevation angle in a significant frequency range for satellite communication links.

10:00 ***Noise Figure of a Unidirectional Cloaking Circuit Based on Parity-Time Symmetry***

Hassan Farooq, Deepak Nagarkoti and Khalid Z Rajab (Queen Mary University of London, United Kingdom (Great Britain)); Yang Hao (Queen Mary University, United Kingdom (Great Britain))

One-way or unidirectional cloaking is realized in RF circuit design using active and passive components that are linked together in parity and time-reversed pairs otherwise known as parity-time symmetry. Such systems provide cloaking and reflectionless transmission properties at the exceptional point where loss and gain of the system are exactly balanced. Here, we estimate the noise figure of a two-port unidirectional cloaking circuit (unit cell) and the impact of noise figure on the radar cross section of a cloaked object.

L_A05 Wear & Implant: L_A05 Wearable and implantable antennas

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Mario Orefice (Politecnico di Torino, Italy), Anja K. Skrivervik (EPFL, Switzerland)

8:40 ***Bluetooth Antenna for Smart Jewellery with Metal Covers***

Rasmus Luomaniemi, Christian Cziezerski and Henri Mäki (Aalto University, Finland); Jari Holopainen (Aalto University School of Electrical Engineering, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

This paper presents a Bluetooth antenna for a smart jewellery with metallic covers on both sides. The antenna design is based on a non-resonant coupling element antenna. The designed antenna is capable of operating both in free space and near a human body, e.g. in the user's hand. The measured prototype achieves over 55% total efficiency in the free space and over 35% total efficiency when measured with a hand phantom in the 2.4-2.48 GHz frequency range.

9:00 ***Fingertip Self-tuning RFID Antennas for the Discrimination of Dielectric Objects***

Giulio M. Bianco (University of Roma Tor Vergata, Italy); Gaetano Marrocco (University of Rome Tor Vergata, Italy)

Self-tuning RFID antennas are based on a new family of multi-state microchips capable of automatically adapting an internal reactive network in order to maximize the power harvested by the attached antenna when boundary conditions change. This concept can be applied to develop a radio-frequency fingertip-augmented device (R-FAD) to be used as dielectric- probe on a finger to discriminate different kinds materials and their discontinuities. When the finger, provided with a self-tuning epidermal tag, comes in touch with an object, the modification of the input impedance of the tag, related to the object's material, can be retrieved by an interrogating reader placed on the wrist. Possible applications concern the aid to impaired people suffering from peripheral neuropathy or eyesight deficiency, but even the inclusion in robotic prosthesis. The modeling and design and characterization of the epidermal self-tuning tag is here presented for the first time and the idea is corroborated by some experimental tests with a system prototype.

9:20 ***A Bandwidth Enhanced 915 MHz Antenna for IoT Wrist-Watch Applications***

Sanjeev Kumar and John Laurence Buckley (Tyndall National Institute, University College Cork, Ireland); John Barton (Tyndall National Institute, Ireland); Robert Newberry (Sanmina Corporation, USA); Gary Dunlop (Sanmina Corporation, Ireland); Matthew Rodencal (Sanmina Corporation, USA); Carlo Webster (Tyndall National Institute, Ireland); Brendan O'Flynn (Tyndall National Institude, Ireland)

This paper presents a 915 MHz planar inverted- F antenna (PIFA) topology for a wrist-worn wireless sensor application. When compared with a conventional PIFA implementation, an impedance bandwidth enhancement of more than 100% is achieved. The bandwidth enhancement is realized with inclusion of a parasitic element that excites an additional mode close to the resonant frequency. A parametric analysis of the key parameters is performed in order to optimize the antenna for 915 MHz operation. The measured results for the on-body prototype antenna show a -10 dB bandwidth of 26.4 MHz and a Peak Realized Gain of -0.57 dBi at 915 MHz. The simulated peak radiation efficiency of 46.8% is achieved. In addition, the design exhibits a low specific absorption rate (SAR) value of 0.004 W/kg.

9:40 ***2G/3G Serpentine Shape Inverted-F Antenna for near Body Application***

Mehdi Seyyedesfahlan (EPFL, Switzerland); Nuno Pires (Geosatis SA & Instituto de Telecomunicações/Instituto Superior Técnico, Switzerland); Anja K. Skrivervik (EPFL, Switzerland)

In this contribution, we present a miniature antenna placed in a leg bracelet for body worn applications. It operates in both the 820-960 MHz and the 1.7-2.1 GHz bands. The radiating element, based on an inverted-F antenna, occupies a 37 mm × 37 mm area and is printed on a flexible substrate that extends a multilayer circuit board. The serpentine shape helps to widen the bandwidths as well as minimize the size. The antenna is characterized for different situations: standalone, inside the plastic casing and worn close to the body inside the same casing. Both simulations and measured results are presented, and they agree well. The design steps are reviewed with the aid of current distribution simulation plots.

10:00 ***Radiation Limitations for Small Implanted Antennas***

Marko Bosiljevac and Zvonimir Sipus (University of Zagreb, Croatia); Anja K. Skrivervik (EPFL, Switzerland)

Medical implants with communication capability are becoming increasingly popular with today's trends to continuously monitor patient's condition. This is a major challenge for antenna designers since the implants are inherently small and placed in a communication-wise very lossy environment. Our goal is to determine the fundamental limitations of such antennas when placed inside human bodies and to develop guidelines for most efficient design. We base our findings on in-house analysis tools based on spherical and cylindrical wave expansion applied to simplified spherical and cylindrical body models respectively. These give us insight into wave propagation and show the maximum power density levels that can be reached just outside the body. Based on the obtained limits we can propose a useful upper bound for more complex scenarios.

F_M01 EMI: F_M01 EMI/EMC/PIM chambers, instrumentation and measurements

TOP

Future Applications / Regular Session / Measurements

Room: Oral Sessions: S4-D - Bytom

Chairs: Francesca Mioc (Consultant, Switzerland), Maria Alberica Saporetti (Microwave Vision Italy, Italy)

8:40 ***On Power Angular Spectrum Estimation in a Reverberation Chamber***

Xiaoming Chen, Teng Li, Ming Zhang, Shitao Zhu and Anxue Zhang (Xi'an Jiaotong University, P.R. China)

The power angular spectrum (PAS) is an important characteristic of the reverberation chamber (RC). Theoretical work suggests that PAS of a well-stirred RC is statistically isotropic, whereas experimental studies show certain degree of anisotropy depending on the RC loading. Since loading is inevitable for both electromagnetic compatibility (EMC) tests and over-the-air (OTA) tests, the PAS is investigated in both frequency and delay domain in this paper. An important finding of this work is that modest loading does not increase the anisotropy in the delay domain. In addition, we show that directive antenna may not be suitable for PAS estimation in the RC and that the periodogram method (for PAS estimation) used in previous literature is equivalent to conventional beamformer, suffering from frequency variation. Instead, a frequency invariant beamformer (FIB) is employed. We further show that the compensation filter of the FIB can actually be approximated by Hankel function of the first kind, simplifying the calculation of the FIB.

9:00 ***Low Passive-Intermodulation Contactless Waveguide Adapter Based on Gap Waveguide Technology***

Xiang Chen (Xi'an Jiaotong University & China Academy of Space Technology (Xi'an), P.R. China); Wanzhao Cui (China Academy of Space Technology Xi'an, P.R. China); Yongning He (Xi'an Jiaotong University, P.R. China); Dongquan Sun (Xidian University, P.R. China)

To solve the passive intermodulation (PIM) of waveguide connection caused by metallic contact, a contactless waveguide adapter (CWA) is proposed, basing on gap waveguide. Two artificial magnetic conductor (AMC) surfaces, in the form of bed of nails, are designed to be a back-to-back structure, composing a contactless transition of waveguide connection. The contact nonlinearity of traditional waveguide flange is dramatically eliminated by contactless design, and PIM is therefore suppressed. The size of the AMC structure is carefully designed to form a proper forbidden band, which prevents electromagnetic (EM) leakage from the contactless air gap. A Ku-band prototype of the CWA is designed and manufactured for standard WR75 waveguide connection. Over the frequency range from 10 to 15GHz, the measured insertion loss and return loss is better than 0.1dB and 20dB respectively. And the PIM performance is improved better than 20dB compared to common waveguide flange connection.

9:20 ***Wideband Suppression of SSN Using Spiral-shaped Localized Defected Structures***

Zhiyi Zhang, JiaHui Fu, Wu Qun, Kuang Zhang and Ao Li (Harbin Institute of Technology, P.R. China)

A simple topology is proposed for mitigating simultaneous switching noise (SSN) in high-speed circuit system, by employing spiral-shaped localized defected structures (LDS) on ground (or power) plane. An accurate equivalent circuit model of proposed structure is presented to analyze its low frequency performance of SSN suppression, which is proved to match the simulated and measured results well. Experimentally, with an extremely small lower cutoff frequency of 145 MHz, a wideband suppression of SSN up to 5.66 GHz is achieved under the criterion of -40 dB. Furthermore, signal integration is discussed and it is found that the proposed structure can minimize the influence of SI.

9:40 ***A Wideband and High Sensitivity Probe Design for Near-Field Scanning***

Rui Yang and Xing-Chang Wei (Zhejiang University, P.R. China)

In this paper, a wideband and high sensitivity magnetic probe is designed for the near-field scanning. To achieve the high sensitivity, the size of the probe aperture is fixed as 1 mm by 1 mm. On the basis of the fixed size, reducing the length of the loop wire and optimizing the width of the loop wire are adopted to reduce the parasitic inductance and capacitance, in order to increase the highest working frequency of the probe. The working frequency of the probe is up to 20 GHz. At the same time, ground planes, metal on sides and shielding vias are used to suppress the unwanted electric field coupling. The tapered trace, shorting via arrays and coax-thru-hole vias are used to improve the performance of the probe further. The probe is fabricated on a four-layered printed circuit board (PCB) with Rogers substrate and calibrated by a standard microstrip line. Finally, a near-field scanning system with the fabricated probe is set up to measure the magnetic field above a Z-type line. From the near-field scanning results, it can be concluded that the probe can measure the magnetic field accurately.

10:00 ***Electromagnetic Time-Reversal Technique for Monitoring Skull Healing Stages***

Javad Ebrahimi Zadeh (The University of Tehran, Iran); Mauricio D Perez (Uppsala University, Sweden & National Technological University, Argentina); Robin Augustine (Uppsala University, Sweden)

This paper provides a novel non-resonant spectroscopy technique for monitoring of the healing process in skull defects created in a cranial surgery. Currently, there is no such method and information on the healing process, which is vital to avoid further complications and for a better understanding of the process. During the healing, which can take several months, the thickness of the skull varies and the permittivity of the defects varies as well. The proposed approach makes use of the approximated Dyadic Green's function integral equation for deriving the variations in permittivity of skull. The scattered electric field from the defect is collected using Time-Reversal Array (TRA) in order to produce the Multi-Static-Data Matrix (MDM). The singular value decomposition on the MDM matrix based on time reversal operator (TRO) decomposition (known under French acronym DORT), provides information of the permittivity of the defect. The problem of the sensing the defect response after the cranial surgery is formulated for multi-layer medium and it will be shown that the dominant singular values are corresponding to the permittivity of the defect. Finally, the veracity of the theory is clarified by conducting a numerical simulation for a planar multi-layer medium consisting of skin, skull and the brain. A defect is placed within the skull. We showed that the dominant singular values corresponding to the defect permittivity varies significantly, which conclude that the dominant singular value can be a good criterion for monitoring the skull healing stages.

H_P03 Propagation: H_P03 Propagation modelling and simulation

TOP

High Data-rate Transfer / Regular Session / Propagation

Room: Oral Sessions: G1- Gniezno

Chairs: Thomas Cwik (NASA-JPL, Caltech, USA), Jochen Moll (Goethe University Frankfurt am Main, Germany)

8:40 ***Numerical and Experimental Analysis of Defect Detection in Jointed Electromagnetic Waveguides***

Jochen Moll (Goethe University Frankfurt am Main, Germany)

Electromagnetic waves in the microwave and millimeter-wave frequency range are used in non-destructive testing (NDT) and structural health monitoring (SHM) applications to detect material defects such as delaminations, cracks or inclusions. This work presents a sensing concept called jointed electromagnetic waveguide, in which the waveguide forms a union with the structure to be inspected. Exploiting ultra-wideband signals a surface defect in the area under the waveguide can be detected and accurately localized. This paper presents numerical and experimental results of the jointed electromagnetic waveguide technology with a focus on detecting through holes and cracks with different orientation. It was found that the numerical model qualitatively replicates the experimental S-parameter measurements for holes of different diameters. A parametric numerical study indicates that the crack parameters such as its orientation and width has a significant influence on the interaction of the incident wave with the structural defect.

9:00 ***Polarization in Spatial Channel Models at mm-Waves: a Correlation Based Approach***

Diego Dupleich (Ilmenau University of Technology, Germany); Robert Müller (TU Ilmenau, Germany); Han Niu and Stephan Häfner (Technische Universität Ilmenau, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

Polarization diversity at mm-waves is under consideration for the new 3GPP release. Since mm-waves systems have higher resolution in the time and angular domain, more accurate intra-cluster models are needed, in which path properties as polarization becomes more deterministic. In the present paper we discuss the limitations of the current modelling of the polarimetric matrix in spatial channel models (SCM) and we propose a new modelling approach including correlation between the different coefficients through the cross-polarization ratios (XPRs) and co-polarization ratios (CPRs). Since path-level information is necessary for this analysis, and due to the lack of high resolution parameter estimation algorithms (HRPEs) at mm-waves, we have performed 60~GHz cluster level measurements to validate ray-tracing simulations that were later used to derive the model parameters.

9:20 ***On Channels with Composite Rough Surfaces at Terahertz Frequencies***

Fawad Sheikh (Universität Duisburg-Essen, Germany); Qammer H Abbasi (University of Glasgow, United Kingdom (Great Britain)); Thomas Kaiser (Universität Duisburg-Essen, Germany)

The paper preliminarily examines the influence of diffuse reflection by composite rough surfaces in ultra-broadband terahertz (THz) communication channels across 300 GHz (0.3 THz) to 310 GHz (0.31 THz) frequency spectrum. At terahertz frequencies, diffuse reflection tends to be higher due to the increased surface roughness and this surface roughness causes an additional attenuation even in a specular direction of reflection (by the amount that is scattered into non-specular directions). Two most famous modeling approaches, Rayleigh-Rice (R-R) and Beckmann-Kirchhoff (B-K) theories are employed to account for the surface scattering and compared by demonstrating the multipath channel transfer function (CTF) dynamics for line-of-sight (LoS) and non-line-of-sight (NLoS) conditions in a simple office environment. The R-R vector perturbation approach predicts diffuse reflection from optically smooth surfaces, whilst classical B-K theory in addition attempts to predict the angular distribution of the scattered field from very rough surfaces. The composite rough surfaces considered in this work have a Gaussian probability density of height and a Gaussian correlation function. Based on these results, it is concluded that the rough surface scattering effects are enhanced at terahertz frequencies and the scattering phenomena show a significant impact, especially in NLoS configuration.

9:40 ***Modelling of Fade Duration Statistics in Earth-Satellite Slant Paths Using Copulas***

Arsim Kelmendi and Andrej Vilhar (Jozef Stefan Institute, Slovenia); Andrej Hrovat (Jožef Stefan Institute, Slovenia); Mihael Mohorcic (Jozef Stefan Institute & Jozef Stefan International Postgraduate School, Slovenia)

Satellite signals in high frequency bands are severely affected by rain, resulting in signal fades. The estimation of fade duration statistics is essential for the design of more efficient fade mitigation techniques for the Earth- satellite communication system. In this paper we present a novel approach for modelling the conditional probability of occurrence of fades and conditional probability of fade time exceeding certain duration and certain attenuation threshold. The method is based on the copula theory for single site slant paths as well as two or multiple site diversity systems. Several copula functions have been tested with good results in the fitting to experimental data. The proposed method may play an important role in the proposing new models for single site fade duration with better performance compared to other existing models and new joint fade duration prediction models in site diversity systems which do not exist yet.

10:00 ***Channel Model Characteristics in D-Band for NLOS Indoor Scenarios***

Laura Pometcu and Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

In this paper we characterize the radio channel characteristics for Line-of-Sight (LOS) and Non-Line-of-Sight (NLOS) indoor scenarios in the 126 - 156 GHz frequency band. Four measurement scenarios have been considered: LOS and NLOS (by human body) in a laboratory and two NLOS (by wall and door blocking) in an office. The power delay profile, angles of arrival, path loss and

delay spread models obtained from the measurements are provided for all configurations.

S_P04 Propagation: S_P01 Propagation experimental methods and campaigns

Space / Regular Session / Propagation

Room: Oral Sessions: G2- Opole

Chairs: Fernando Pérez-Fontán (University of Vigo, Spain), Gustavo Siles (Universidad Privada Boliviana, Bolivia)

8:40 ***Propagation Study at 4065 Meters of Altitude Attenuation Due to Gases at Ka, Q, V and W Bands Using Radiosonde Observations***

Gustavo Siles (Universidad Privada Boliviana, Bolivia); Miguel Heredia (Agencia Boliviana Espacial, Bolivia); Marcelo Vilela (Universidad Privada Boliviana, Bolivia)

The present contribution is part of a study aimed to characterize the propagation conditions at high altitude sites, as a collaboration between Universidad Privada Boliviana and Agencia Boliviana Espacial, which currently operates a Satellite Ground Control Station located above 4000-m a.m.s.l. A 2-year database of radiosonde observations carried out once a day at La Paz/El Alto Airport, located 13 km apart from the station, at 4065-m a.m.s.l and 50 m of height difference, is exploited with the aim of estimating gaseous attenuation at Q, V and W bands. The calculations have been performed using the line-by-line method of the ITU-R P.676 Recommendation and compared to approximate methods. Results show a higher impact of attenuation caused by oxygen at 40, 50 and 75 GHz in relation to water vapor effects and prediction errors of approximate methods between 5% and 10% under these particular geographical conditions.

9:00 ***Event Analysis Using the Modified Synthetic Storm Technique in Orbit-Diversity Satellite Links at Ka-Band***

Fernando Pérez-Fontán, Vicente Pastoriza and Fernando Machado (University of Vigo, Spain); Dalia (Das) Nandi (Indian Institute of Information Technology, India)

In this paper we observe the simultaneous evolution of rain events "seen" with two Ka-Band beacon receivers looking at two different satellites. We are looking into their similarities and differences and whether, having storm speed and direction, can improve the performance of the Synthetic Storm Technique.

9:20 ***4.9 GHz Band Outdoor to Indoor Propagation Loss Analysis in High Building Environment Using Unmanned Aerial Vehicle***

Kentaro Saito, Qiwei Fan, Nopphon Keerativoranan and Jun-ichi Takada (Tokyo Institute of Technology, Japan)

User traffic of mobile wireless communication is rapidly increasing in urban areas. Thus, service cell planning of the networks becomes an important issue for efficient radio resource usage. Since many users are also inside high buildings in those areas, it is important to know the building entry loss (BEL) characteristics from the outside base stations (BSs) of various locations for the purpose. In this study, we developed a radio measurement system using an unmanned aerial vehicle (UAV). The system can improve the degree of freedom of the outdoor BS placements drastically. We performed 4.9 GHz band BEL measurements in a high-building environment. Through the comparison to the ray-tracing simulation, we found that the existence of direct and reflection waves from the interior wall and structures such as the window fence dominated the BEL characteristics. The results can be utilized for cell planning in urban high-building environments.

9:40 ***Statistical Characterization of Slant-Path Atmospheric Channels Exploiting Microwave Sun-tracking Radiometer***

Marianna Biscarini and Luca Milani (Sapienza University of Rome, Italy); Mario Montopoli (ISAC CNR, Italy); Klaide De Sanctis (HIMET, Italy); Saverio Di Fabio (CETEMPS, Italy); Kevin Magde and George Brost (Air Force Research Laboratory, USA); Frank S. Marzano (Sapienza University of Rome, Italy)

The objective of this work is to propose a model for the computation of the conditional probability density function (PDF) of the atmospheric attenuation and brightness temperature given the elevation angle variations during a satellite-to-Earth link. The proposed model was developed exploiting measurements from a Sun-tracking microwave radiometer sited in Rome, NY (USA), available at 23.8, 31.4, 72.5 and 82.5 GHz. The model can be used to retrieve the total PDF of the considered radio-propagation parameter (attenuation or brightness temperature) taking into account for the variations of the elevation angle of the considered link. The proposed model is function of the statistical parameters (mean and standard deviation) of the attenuation and brightness temperature of the considered geographical area. The preliminary results presented in this paper are promising with root mean square errors, in terms of total PDF, always smaller than 0.04 and 0.004 for attenuation and brightness temperature, respectively.

10:00 ***Comparison of Integrated Digital Radiometer with Concurrent Water Vapor Radiometer Using the Alphasat Receivers in Milan, Italy***

Michael Zemba and James Nessel (NASA, USA); Lorenzo Luini and Carlo Riva (Politecnico di Milano, Italy)

In June 2014, NASA Glenn Research Center (GRC) and the Politecnico di Milano (POLIMI) jointly deployed a pair of coherent 20 GHz and 40 GHz beacon receivers to the POLIMI campus in Milan, Italy to characterize the atmospheric channel at Ka- and Q-band within the framework of the Alphasat experiment. The Milan receivers observe the continuous-wave beacons broadcast over Europe by the Aldo Paraboni Technology Demonstration Payload (TDP #5), and, in September 2017, both channels were upgraded to incorporate a novel digital radiometer (DR) measurement which NASA has recently employed in other propagation measurement campaigns. In November 2016, a co-located water vapor radiometer (WVR) was also installed at POLIMI, and the concurrent data from both the WVR and DR thus enables validation of this new DR technique against the established WVR. Herein, we preliminarily investigate the calibration of the DR measurements using the WVR data and also assess a calibration method that may be implemented where WVR data is not readily available.

B_P01 Propag Bio: B_P01 Propagation in Biological Tissues

Biomedical / Regular Session / Propagation

Room: Oral Sessions: A2- Ustka

Chairs: Sina Rezaei Aghdam (Chalmers University of Technology, Sweden), Guido Valerio (Sorbonne Université, France)

8:40 ***Spatial Resolution Evaluation of a Microwave System for Breast Cancer Screening***

Daniel Tajik, Jessica Trac and Natalia Nikolova (McMaster University, Canada)

The ability of microwave breast imaging to achieve sub-centimeter spatial resolution has been proven before in simulation and simple experimental studies. However, detecting sub-centimeter tumours depends not only on the theoretical spatial resolution limit, but also on the level of background clutter and measurement uncertainty. Therefore, estimating the actual limit of the smallest detectable object in a specific measurement setup is critical before the setup can be deployed in a clinical scenario. Here, we present a method of such evaluation on a planar microwave imaging setup for breast cancer imaging. The method utilizes the measurement of a small scattering probe of known size and permittivity in a uniform embedding medium. The contrast-to-noise ratio (CNR) of the generated point spread function can then be evaluated to determine the system-specific spatial resolution. The effectiveness of this approach is demonstrated in an experimental study of a compressed-breast phantom. This method can be applied to evaluate the limit of the size of detectable objects for other acquisitions systems, e.g. hemispherical or cylindrical antenna configurations.

9:00 ***Reducing Motion Artifacts in Microwave-Based Hemorrhagic Stroke Detection***

Sina Rezaei Aghdam, Andreas Fhager, Christian Fager and Thomas Eriksson (Chalmers University of Technology, Sweden)

The use of microwave technology for brain stroke detection opens up the opportunity for developing low-cost transportable devices which can be employed for rapid and prehospital detection of bleeding in patients with traumatic brain injury. Since the detection relies on changes in the scattering parameters of the tissues during pathological conditions, the movements in head or the antennas can deteriorate the detection accuracy. As a countermeasure to this problem, we introduce a technique for reducing the sensitivity of the detection system to motion artifacts. Via analyzing the scattering from an anatomically accurate model of human brain, we evidence that the channels between different pairs of antennas exhibit significantly different levels of sensitivity to the movement. Using this as a ground truth, we develop a generalized singular value decomposition (GSVD)-based approach for assigning appropriate weights to the channels between different antennas such that the probability of correct bleeding detection is maximized.

9:20 ***Electromagnetic Monitoring of Biological Microorganisms***

Faezeh Zarrinkhat and Alejandra Garrido (Universitat Politècnica de Catalunya, Spain); Luis Jofre (Universitat Politecnica de Catalunya, Spain); Jordi Romeu and Juan M. Rius (Universitat Politècnica de Catalunya, Spain)

The investigation of the electromagnetic properties of biological cells in the microwave frequencies range may enable wireless monitoring of functional activity of microorganisms. A theoretical and an experimental methodology is applied to obtain the electromagnetic characterization of the E. Coli cells as a simple microorganism at the microwave frequencies. The simulation and experimental results corresponding to the transmission coefficient and sensitivity of a coaxial set-up for different concentration of E. Coli cells are measured up to 3GHz. As a second step, the E. Coli is used as the basis to approach the electrical changes, in terms of extension and contrast, involved into the creation of a functional activity (action potential) of a neuronal cell.

9:40 ***Alternating Projections of Auxiliary Vector Fields for Electric Field Optimization in Temperature-guided Hyperthermia***

Christos Liontas (Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, Germany)

We present an alternating projections algorithm (APA) for optimizing the excitations of an antenna array in hyperthermia treatment. The algorithm is based on auxiliary (artificial) complex-vectorial fields that can be derived from temperature or SAR (specific absorption rate) values. These values can be estimated in real-time with the help noninvasive thermometry, like Magnetic Resonance (MR) temperature estimation. The algorithm is tested on data from full-wave simulations of an Agar-gel phantom that is irradiated by a six-element annular array of dipoles. It is shown that, depending on the size and location of the region to be heated, the APA algorithm can outperform the usual eigenvalue optimization with respect to hotspot suppression.

10:00 ***Surface and Volumetric Modes of Resonators Based on Periodic Wires for MRI Applications***

Stanislav Glybovski, Georgiy Solomakha, Anna Hurshkainen, Anton Nikulin and Dmitry A Dobrykh (ITMO University, Russia); Redha Abdeddaim (Aix Marseille University, France); Alexey P. Slobozhanyuk (ITMO University & Australian National University, Russia); Alena Shchelokova (Birjevaja line 14 & ITMO University, Russia); Alexander Kozachenko (ITMO University, Russia); Alexander Efimtcev (Federal North-West Medical Research Center, Russia); Irina V. Melchakova (ITMO University, Russia); Stefan Enoch (CNRS & Institut Fresnel, France); Pavel Belov (ITMO University, Russia)
In this work we demonstrate that periodic arrays of thin metal wires properly interconnected with lumped capacities can serve as combined surface and volumetric resonators of inductively-coupled radiofrequency coils for MRI. We investigate the surface and volumetric fundamental eigenmodes of a novel resonator formed by two parallel arrays of capacitively-loaded wires in terms of their magnetic field distributions. The proposed resonator can be used in coils for clinical and research MRI.

Friday, April 5 10:50 - 12:30

Sp_A04 Reflect Arrays 2: Sp_A04 Reflect Arrays 2

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Space / Regular Session / Antennas

Room: Oral Sessions: S2 – Warszawa

Chairs: Manuel Arrebola (Universidad de Oviedo, Spain), Eduardo Martinez-de-Rioja (Universidad Politecnica de Madrid, Spain)

10:50 ***Multiple Scanning Beam Antenna Configuration for Space Applications Using Reflectarrays***

Shigeru Makino (Kanazawa Institute of Technology, Japan); Hiromasa Nakajima and Michio Takikawa (Mitsubishi Electric Corporation, Japan)
Some multiple spot beam antenna systems using two reflectarrays have been proposed to reduce the numbers of antennas for space applications. In either antenna system, an antenna is shared by Tx band and Rx band, so when the frequency bands are far apart between Tx and Rx such as Ka band, some problems will occur as follows: > Beam widths are different, so beam arrangement will be difficult. > The feeding circuit connected to each feed horn will become complicated. In this presentation, a new satellite antenna system using multiple scanning beam reflectarrays will be proposed, where the antenna system is composed of a Tx and a Rx antenna. Further, each antenna is composed of a single-layer flat reflectarray and multiple horns. Important points of reflectarray design are as follows: > By arranging a plurality of scanning beams utilizing the beam squint characteristics of the reflectarray in elevation, the elongated areas are covered. > By using the appropriate phasing elements, scanning beams with different directions in azimuth due to polarization are radiated. So, the service area is covered with the elongate beams staggered by orthogonal polarization. As a results, users within the service area can use a half of the frequency band if 3 dB gain reduction is allowed, like the conventional antenna systems.

11:10 ***Preliminary Simulations of a 1.8-M Reflectarray Antenna in a Geostationary Satellite to Generate Multi-Spot Coverage***

Daniel Martinez-de-Rioja (Universidad Politécnica de Madrid, Spain); Eduardo Martinez-de-Rioja and Jose A. Encinar (Universidad Politecnica de Madrid, Spain)
This contribution presents preliminary results of a 1.8-m reflectarray antenna proposed to generate a complete multi-spot coverage for transmission in broadband satellite communications in Ka-band. The antenna is designed according to a recently validated design method of reflectarrays which allows to produce four adjacent beams per feed by discriminating simultaneously in frequency and polarization. The simulations consider 27 dual-polarized feeds to illuminate the reflectarray, so the 1.8-m reflectarray is expected to generate 108 beams separated 0.56 degree at two frequencies and two polarizations. The concept enables a reduction in the number of antennas and feeds required on board geostationary communication satellites to provide multi-spot coverage in Ka-band.

11:30 ***Design of Bifocal Dual Reflectarray Antennas in Ka-band to Generate a Multi-Spot Coverage from Geostationary Satellites***

Eduardo Martinez-de-Rioja and Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Antonio Pino and Borja Gonzalez-Valdes (University of Vigo, Spain)
This contribution studies the use of bifocal dual reflectarray antennas to provide multi-spot coverage from a geostationary satellite operating in Ka-band. A general 3D bifocal technique has been applied to design a multi-beam dual reflectarray antenna in an offset compact-range configuration, considering three different degrees of beam spacing compression (high, low and no compression) with respect to the equivalent monofocal antenna. The results of the design (bifocal phase distributions, radiation patterns, etc.) have been compared for the three cases under study. The use of suitable reflectarray cells will allow to produce independent beams in each polarization (two beams per feed), so that the bifocal antenna will provide adjacent beams in orthogonal polarizations with 0.56º angular spacing.

11:50 ***Computationally-Efficient Synthesis of Advanced Reflectarrays Through a System-by-Design Tool***

Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Marco Salucci (ELEDIA Research Center, Italy); Angelo Gelmini (ELEDIA Research Center, University of Trento, Italy); Andrea Massa (University of Trento, Italy)
This work presents an innovative computationally-efficient methodology for the synthesis of reflectarrays through the System-by-Design (SbD) paradigm. The proposed approach integrates different analysis and synthesis functional blocks in order to yield effective solutions while reducing the computational burden of the design procedure. Towards this end, a fast surrogate model is used to predict the electromagnetic response of each candidate solution, while a global optimizer is used to effectively explore the search space and synthesize a reduced-complexity reflectarray surface layout satisfying specific radiation features.

12:10 ***Reflectarray Design for Satellite Applications with Very Low Cross-Polarization Requirements***

Daniel R. Prado (Heriot Watt University & School of Engineering & Physical Sciences, United Kingdom (Great Britain)); Manuel Arrebola (Universidad de Oviedo, Spain); George Goussetis (Heriot-Watt University, United Kingdom (Great Britain))
Modern satellite applications for communications require a high polarization purity, usually with parameters such as the crosspolar discrimination (XPD) larger than 33 dB. To achieve these values, some form of cross-polarization performance optimization must be carried out. The usual approach is to minimize the crosspolar component of the far field with regard to the copolar pattern in the region of interest. However, this generates suboptimal results since the figure of merit for crosspolarization performance, i.e. the XPD, is optimized indirectly. Thus, it is proposed to directly optimize the figure of merit to considerably improve the polarization purity of reflectarray antennas for satellite applications. For that purpose, the generalized Intersection Approach algorithm is used in a large reflectarray for a contoured beam application with European coverage. It is shown that directly optimizing the cross-polarization figure of merit provides better results than the usual approach of minimizing the crosspolar pattern.

F_A10 Meta EBG: F_A10 Metamaterials, metasurfaces and EBG for antennas

TOP

Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-A – Gdansk

Chairs: Slawomir Hausman (Lodz University of Technology, Poland), Wanzhao Cui (China Academy of Space Technology Xi'an, P.R. China)

10:50 ***Optimization of an Artificial Magnetic Conductor Geometry Using a Paretian Approach***

Lukasz Jopek (Institute of Electronics, Lodz University of Technology, Poland); Slawomir Hausman (Lodz University of Technology, Poland); Paolo Di Barba (University of Pavia, Italy)
A bi-objective Pareto-like genetic algorithm optimization approach for a cross-shaped Artificial Magnetic Conductor (AMC) geometry is proposed and investigated by means of simulations. Each elementary cell of this periodic AMC structure has nine geometry parameters. Its performance is improved with respect to two objective function components, i.e. deviation from the desired 0deg reflection phase shift frequency and the bandwidth defined for the reflected wave phase shift between -90deg to +90deg. The proposed approach can be used to design AMCs for various antenna applications.

11:10 ***A Compact Waveguide Connection for Space Applications Using Gap Waveguide Technology***

Wanzhao Cui (China Academy of Space Technology Xi'an, P.R. China); Xiang Chen (Xi'an Jiaotong University & China Academy of Space Technology (Xi'an), P.R. China); Yongning He (Xi'an Jiaotong University, P.R. China); Dongquan Sun (Xidian University, P.R. China)
A compact waveguide connection (CWC) is proposed using gap waveguide (GW) technology. Periodic artificial magnetic conductor (AMC) is designed surrounding the outer surface of one waveguide. Another waveguide is designed with an enlarged hollow end, whose inner surface works as the PEC surface. The profile size of the AMC structure is designed to be same as the inner cavity of the hollow end. The AMC part is inserted into the hollow end, composing a tight connection. The dimensions of the AMC structure are carefully designed to form a forbidden band to prevent electromagnetic leakage from the tiny air gap caused by machining error. A Ku-band prototype of the CWC is manufactured and test. The measured insertion and return loss is better than 0.06dB and -30dB respectively over the frequency range from 10~15GHz, the size of the proposed CWC decreases by more than 60% comparing with traditional waveguide flange.

11:30 ***Scattered Field Solutions of Uniform Metasurfaces Using Plane-Wave Decomposition Method for Arbitrary Incident Waves***

Scott Stewart, Sanam Moslemi-Tabrizi, Tom Smy and Shulabh Gupta (Carleton University, Canada)
A semi-analytical method of calculating scattered fields from a uniform metasurface for an arbitrary monochromatic incident field is presented and confirmed with numerical simulations. A known incident field is first decomposed using a Fourier transform into a set of plane waves, and Generalized Sheet Transition Conditions (GTSCs) are next applied to each plane wave component to accurately determine the total scattering fields in the transmission and reflection regions. The proposed semi-analytical method represents a simple benchmarking tool to validate various numerical methods for analyzing metasurfaces.

11:50 ***Enhanced Scanning Range Design for Leaky-Wave Antenna (LWA) at 60 GHz***

Qiang Zhang (Sorbonne Université UPMC, France); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France); Guido Valerio (Sorbonne Université, France); Philippe De Doncker (ULB, Belgium); Aziz Benlarbi-Delaï (Sorbonne University, Paris, France)

The benefits of metasurface-based Leaky-Wave Antennas (LWA) over more conventional LWA is assessed in terms of angular scanning. In order to achieve a fast-angular scanning with frequency, a highly-dispersive waveguide is classically required. The additional degree of freedom offered by a surface impedance, here implemented with a grid of square patches enables increasing the dispersion. Using this enhanced dispersion, a LWA is designed and simulated in the 60 GHz band. It is shown that the obtained scanning range is increased by a 2.6 factor with respect to a classical LWA composed of metallic strips over a grounded dielectric Slab. A scanning range from -52° to -16° has been thus obtained with a 11.6% frequency bandwidth.

F_A09 Small Ant: F_A09 Small antennas

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Future Applications / Regular Session / Antennas

Room: Oral Sessions: S3-B - Wroclaw

Chairs: Serge Bories (CEA, France), Ala Sharaiha (Université de Rennes 1 & IETR, France)

10:50 ***A Coplanar-Strip-Based Excitation Technique for Wide 3-dB Axial Ratio Beamwidth and Enhanced Circular Polarization Antenna***

Ubaid Ullah (Reykjavik University, Iceland); Slawomir Koziel (Gdansk University of Technology, Poland)

This paper presents a new feeding technique for excitation of circular polarization (CP) in a planar wide-slot antenna with enhanced axial ratio (AR) bandwidth and wide 3 dB AR beamwidth. To achieve a wide 3 dB AR beamwidth, two parasitic L-shape strips are positioned coplanar to the microstrip line extension of an asymmetrical coplanar waveguide (CPW). For additional CP modes, a horizontal strip is protruded from the vertical edge of the ground plane towards the center of the slot etched in the ground plane. With this technique, not only the 3 dB AR beamwidth is improved but also a wide AR bandwidth is obtained. The total footprint of the antenna realized using the outlined approach is Ls × Ws = 0.3 λ0 × 0.28 λ0 with λ0 being the free space wavelength at the lowest operating frequency of the antenna. Additionally, a wide impedance bandwidth of up to 72-percent (2.26 GHz-4.85 GHz) is achieved along with the AR bandwidth of 66% (2.44 GHz- 4.87 GHz). Furthermore, for the 58-percent of the total AR bandwidth a wide 3 dB beamwidth of 85° ± 5° is maintained without involving any complex circuitry. Finally, the antenna features realized gain of 3.7 dBi (averaged over the entire operating band).

11:10 ***A Non-foster Matching Circuit for an Ultra-wideband Electrically Small Monopole Antenna***

Yinfeng Xia and Yingsong Li (Harbin Engineering University, P.R. China); Shuai Zhang (Aalborg University, Denmark)

In this paper, a negative-capacitance non-foster circuit (NFC) is designed to match an electrically small monopole antenna with a height of 300 mm. Since the effectiveness of an electrically small antenna is severely limited by gain-bandwidth theory due to high-Q impedances, a non-foster circuit is proposed to overcome this limitation. The proposed circuit is verified by using co-simulation based on HFSS and ADS, and the results indicate that the electrically small monopole antenna is well matched to the designed NFC with a bandwidth of 173%, which ranges from 16 MHz- 222MHz.

11:30 ***Comparison of Two Small Circularly Polarized Antennas for Focused Microwave Hyperthermia***

Jianian Li and Xiong Wang (ShanghaiTech University, P.R. China)

Focused microwave hyperthermia is an attractive treatment technique for breast cancer owing to its high accuracy and efficiency. It requires an antenna array to radiate microwave fields into a breast and iteratively focuses the fields at a breast tumor by optimizing excitation phases and amplitudes of the array. Only linearly polarized antenna elements have been applied for the focused microwave hyperthermia. This work investigates the feasibility of employing circularly polarized antennas for the purpose of focused microwave hyperthermia. Two kinds of circularly polarized antennas are applied and their dimensions are miniaturized to enable arrangement of more antennas around a human breast. Simulation results show that both the tested antennas can obtain microwave field distributions well focused at the tumor in a breast model. Therefore, circularly polarized antennas are suitable for focused microwave hyperthermia.

11:50 ***Generalization of King IFA Model for Lossy Loaded Antenna Miniaturization***

Rana Berro (Grenoble Alpes University & CEA LETI, France); Serge Bories (CEA, France); Christophe Delaveaud (CEA-LETI, France)

A general transmission line model of a lossy inverted F antenna is derived in this work to allow the study of the radiation performances of the antenna regarding the miniaturization technique. The model allows to assess input impedance, radiation efficiency and currents at any points of the structure. It shows high accuracy with a maximum error of 1.1% compared to CST MWS simulations. This analytical Transmission Line model will allow to study and optimize tunable miniature IFA performance as function of the loading component characteristics.

C_A02 MM Submm THz: C_A02 Millimeter, sub-millimeter and TeraHertz antennas

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Cellular Communications / Regular Session / Antennas

Room: Oral Sessions: S4-A - Poznan

Chairs: Huan-Chu Huang (vivo Mobile Communication Co., Ltd, Taiwan), Traianos Yioultsis (Aristotle University of Thessaloniki, Greece)

10:50 ***Novel Integrated Design of a Dual-Band Dual-Polarization 5G mm-Wave Antenna Array with a U-Slotted Full-Metal Casing for a Cellular Phone***

Huan-Chu Huang (vivo Mobile Communication Co., Ltd, Taiwan); Yijin Wang and Xianjing Jian (vivo Mobile Communication Co., Ltd, P.R. China)

A novel integrated design of a dual-band dual-polarization millimeter-wave (mm-Wave) antenna array to a full-metal casing with U-shaped slots of a cellular phone with a high screen-to-body ratio (based on the display active area) over 94.5% for the fifth generation mobile communications (5G) technology is proposed and this integrated design is promising to the future potential attractive antenna solution of mm-Wave antennas in non-mm-Wave antennas (AiA) especially when a metal frame or a metal casing is applied to the exterior of a cellular phone. The novel mm-Wave antenna array is based on 5 dual-band dual-polarization stacked patch antennas embedded in the metal exterior. Bases on simulations, in terms of input reflection coefficients |Snn| ≤ -10 dB, the bandwidths of the ports (V-ports) in the mm-Wave antenna array for the vertical-polarization (V-pol.) range from 27.38 GHz to 28.49 GHz and from 36.92 GHz to 40.23 GHz, respectively; similarly, the bandwidths of the ports (H-ports) in the mm-Wave antenna array for the horizontal-polarization (H-pol.) range from 27.29 GHz to 28.54 GHz and from 36.94 GHz to 40.37 GHz, respectively. In other words, the 5G mm-Wave bands of n261 (27.5-28.35 GHz) and n260 (37.0-40.0 GHz) in the third generation partnership project (3GPP) can be hence accommodated by this presented design. The maximum V-pol. peak realized gains in the low band (band n261) and high band (band n260) are 11.64 dBi and 13.36 dBi, and both of the maximum scanning angles for the two band are 45°. Similarly, the maximum H-pol. peak realized gains in the low band and high band are 11.38 dBi and 12.13 dBi, and the maximum scanning angles are 60° and 30°, respectively. Additionally, in this design, owing to the ground shading of the recessed metal cells, the performance of the antenna array will be not so susceptible to the display, metal back cover, or feeding structures. As a result, the conformal feeding mechanism can thus be employed easily.

11:10 ***Millimeter-wave Near-field Spectrum Analyzer Based on Integrated Side-fire Antennas***

Daniel King, Mohamed K. Emara and Shulabh Gupta (Carleton University, Canada)

A real-time, low-profile and shielded real-time spectrum analyzer is proposed for operation at mm-wave frequencies based on Substrate Integrated Waveguide (SIW) technology. A novel unit cell is also proposed to enable an in-plane side-fire radiating Leaky Wave Antenna (LWA). The unit cell is inspired from a conventional T-junction and is equipped with an internal matching mechanism to suppress stop-band to achieve full-space radiation. The antenna characteristics and the system operation is confirmed using full-wave simulations. The proposed system is analog, broadband, real-time in nature, low-profile and compact in size, ideal for instrumentation applications.

11:30 ***Integrated Metal-lens Antennas with Reduced Height at 71-76 GHz***

Sabin Karki and Juha Ala-Laurinaho (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

A low-profile lens antenna with high efficiency is desired in many millimeter-wave applications. In this work, a new approach to integrate a dielectric lens and a metal-lens is studied to minimize the lens height. The proposed integrated metal-lens antenna minimizes the height while maintaining aperture efficiency close to that of traditional elliptical integrated lens antennas. In case of low permittivity materials, the height of the designed lens can be 35% smaller. An integrated metal-lens antenna with 8λ_0 radius is designed with Teflon (εr = 2:1 and tanδ = 0.0002) and 0.575λ_0 parallel plate separation for operation at lower E-band, i.e., 71-76 GHz. The simulated boresight directivity of the designed lens is 32.6 dB and the peak aperture efficiency is 80%. The 3-dB gain bandwidth of the designed dual-polarized integrated metal-lens antenna is approx. 10% and the gain scan loss is 7.4 dB for beam steering range of ±30°.

11:50 ***Wideband Dual-polarized Array Antenna on Dielectric-based Inverted Microstrip Gap Waveguide***

Tianling Zhang, Lei Chen, Sadegh Mansouri Moghaddam, Ashraf Uz Zaman and Jian Yang (Chalmers University of Technology, Sweden)

A wideband dual-polarized planar array antenna is presented in this paper. The proposed array antenna consists of 8×8 bowtie antennas and dielectric-based inverted microstrip gap waveguide network. It is composed of multilayer substrate which can be fabricated by low cost PCB process. The simulated results show that the proposed array achieves a relative impedance bandwidth of 62% from 17.7GHz to 34 GHz for both polarizations with VSWR of 2.

12:10 ***Design of a Fully Planar BC-CSRR SIW-based H-plane Sectoral Horn with a Printed Transition***

Vasileios N. Salonikios, Michalis Nitas, Savvas Raptis and Traianos Yioultsis (Aristotle University of Thessaloniki, Greece)

The Broadside Coupled Complementary Split Ring Resonator Substrate Integrated waveguide (BC-CSRR SIW) is a fully planar platform for the implementation of millimeter-wave components at a minimal fabrication cost. We present here a new design H-plane sectoral horn Antenna based on the BC-CSRR SIW. A transition of parallel plate strips etched on the same substrate is also designed using parametric finite element simulations, in order to improve matching and radiation characteristics. The composite antenna comprising of the BC-CSRR SIW horn and the matching transition exhibits good return loss performance and directive end fire radiation, while the back radiation is kept small.

MT_A03 Array Ant: MT_A03 Array antennas, antenna systems and architectures

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High Data Rate / Biomedical / Regular Session / Antennas

Room: Oral Sessions: S4-B - Lublin

Chairs: Pietro Bolli (INAF - Osservatorio Astrofisico di Arcetri, Italy), Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

10:50 ***Study of Impedance Matching in Antenna Arrays Due to Total Radiation***

Irfan Ali Tunio (University of Nantes, France); Yann Mahe (Lunam Université - Université de Nantes, IETR, France); Tchanguiz Razban and Bruno Froppier (University of Nantes, France)

The phenomenon of impedance mismatching in antenna arrays is a potential source of performance degradation, particularly when huge number of antenna elements are placed side by side. Therefore, from its noticeable impact on the performance of communication components and systems, arose the necessity of studying the phenomenon of mismatching so as to minimize its effect. However, in an array of antennas, each antenna appears to be matched when measured individually. Nevertheless, the problem of mismatching reveals itself strongly when the whole array is set to radiate. The value of the input impedance of individual antenna elements changes versus antenna number and position. In this research, the impact of total radiation from an array on input impedance of individual antenna elements is analyzed through theory. The obtained results are compared through simulations and measurements.

11:10 ***Near Field Approximation for Wireless Power Transfer by MoM***

Linh Ho Manh and Quan Dinh Hong (Hanoi University of Science and Technology, Vietnam); Le Hoang (Soongsil University, Korea); Hung Nguyen Tuan (Le Quy Don Technical University, Vietnam); Paola Pirinoli (Politecnico di Torino, Italy); Chien Ngoc Dao (Hanoi University of Science and Technology, Vietnam)

In wireless power transfer systems, to know the near field radiated by the antenna is of primary importance, since it is through it that the coupling and the transfer of power occurs. Commercial full-wave simulator are good references for near field calculation however, its evaluation on an arbitrary surface is not straightforward. In this paper, the computation of the field radiated in the Fresnel region by a transmitting antenna is performed, recurring to a numerical approach based on the Method of Moments. Results for both a single E-shape element and a 4x4 array are presented. Details of the calculations are also presented in the paper

11:30 ***Mutual Coupling Analysis for a SKA1-LOW Station***

Paola Di Ninni (INAF - Osservatorio Astrofisico di Arcetri, Italy); Mirko Bercigli (IDS Ingegneria Dei Sistemi S. p. A, Italy); Pietro Bolli (INAF - Osservatorio Astrofisico di Arcetri, Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Stefan J. Wijnholds (ASTRON, The Netherlands)

The modelling of the antenna patterns represents one of the main challenges for the instrumental calibration of radio telescopes composed by antennas randomly distributed. In this work, the electromagnetic characterization of a single station of the low-frequency instrument of the Square Kilometre Array (SKA) radio telescope operating from 50 to 350 MHz is reported. The station is assumed to be composed by Log Periodic antennas. The effects of mutual coupling on the complex embedded element patterns and on the array beam are investigated by means of a full-wave electromagnetic analysis. The accuracy of a simplified, mutual coupling-free approach is presented as well.

11:50 ***Spherical Coverage Characterization of Millimeter Wave Antenna Arrays in 5G Mobile Terminals***

Ali Hazmi (Magister Oy & Huawei Technologies, Finland); Ruiyuan Tian and Sami Rintamaki (Huawei Technologies, Finland); Zlatoljub Milosavljevic (Huawei Technologies Oy (Finland) Co. Ltd, Finland); Janne Ilvonen (Aalto University School of Electrical Engineering, Finland); Jari Wonterghem (Huawei Technologies, Finland); Alexander Khripkov (Huawei Technologies LTD, Finland); Timofey Kamyshev (Huawei Technologies, Finland)

This paper studies and compares the spherical coverage performance of typical millimeter wave antenna array configurations in a 5G mobile terminal using the cumulative distribution function as a basic figure of merit. The performance comparison is illustrated using distributed antenna arrays operating at 28 GHz with different antenna element locations on the mobile terminal. The study shows the pros and cons of each antenna array configuration with respect to coverage and peak gain. In addition, the study provides guidelines on how the antenna array elements need to be distributed and highlights the importance of placing the antenna elements on the mobile device's display side in order to achieve a given effective isotropic radiated power requirements both in free space and user scenarios with a hand phantom.

12:10 ***Superdirective Dipole Arrays***

Tomas Lonsky (Czech Technical University, Czech Republic); Pavel Hazdra and Jan Kracek (Czech Technical University in Prague, Czech Republic)

In this paper we develop and utilize theory for finding excitation currents that maximize the directivity of arbitrary dipole arrays. Such excitation is known as superdirective. It is shown that for arrays above perfectly electric ground, the corresponding optimal currents are purely real. It is also observed that for horizontally oriented dipoles, there exist optimum for spacing and height producing maximum obtainable directivity.

L_A06 Multiband & wideband: L_A06 Multiband and wideband antennas

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Oral Sessions: S4-C - Kielce

Chairs: Stanislav Glybovski (ITMO University, Russia), Alexander Vorobyov (CSEM & Center Suisse d'Electronique et de Microtechnique SA, Switzerland)

10:50 ***A Novel Miniaturized Broadband Yagi-Uda Antenna with Enhanced Gain for Wireless Energy Harvesting Applications***

Sumin David Joseph and Yi Huang (University of Liverpool, United Kingdom (Great Britain)); Shuohung Hsu (National Tsinghua University, Taiwan); Manoj Stanley and Ahmed Alieldin (University of Liverpool, United Kingdom (Great Britain)); Chung-Hsin Li (National Tsinghua University, Taiwan)

A miniaturized constant high gain broadband Yagi-Uda antenna is designed for wireless energy harvesting applications. The proposed antenna consists of two meandered dipoles connected using feed lines serves as the radiating element for realizing the broadband. A highly compact antenna is realized using curved reflectors and meandered dipoles and director. To maintain constant enhanced gain throughout the band, the reflector is designed to provide better performance at lower frequencies and to improve the front to back ratio. The meandered director is optimized for gain enhancement at higher frequencies. This design strategy helps to achieve a directivity of more than 6 dBi throughout the band from 1.65 to 2.5 GHz to cover the cellular and WLAN bands. The proposed antenna has a small antenna footprint (55 mm × 64 mm) making it a good solution for wireless energy harvesting.

11:10 ***Efficient, Compact 868MHz Antenna for Retrofit of Electronic Appliance***

Alexander Vorobyov (CSEM & Center Suisse d'Electronique et de Microtechnique SA, Switzerland); Philippe Dallemagne (CSEM, Switzerland)

This paper describes a wire loop antenna with a parasitic element, designed for use in smart smoke detector, acting as a wireless gateway. The antenna has been designed, prototyped and tuned to 868MHz band, then it was characterised and tested in real environment. The antenna can easily be tuned to the 2.45GHz ISM band, and then used by Bluetooth and WiFi devices.

11:30 ***A Comparison of Three Feeding Networks for CubeSat L/S-dual-band Stacked-Patch Antennas***

Miroslav J. Veljovic and Anja K. Skrivervik (EPFL, Switzerland)

The CubeSat nanosatellite standard puts strict limitations on the antenna volume, resulting in a low impedance and axial-ratio (AR) bandwidths of patch antennas. The AR of a circularly polarized patch antenna can be improved with the introduction of a dedicated feeding network. However, the antenna gain cannot be influenced, and it will be comparable to a conventional single-feed CP patch. This is demonstrated on three different feeding networks for dual-feed stacked-patch antennas in L and S bands, based on T-junction dividers, Wilkinson dividers, and branchline couplers. Based on their performance and size, the model based on Wilkinson dividers has the optimal performance for CubeSat applications in L and S bands.

11:50 ***Dual-Band Compact Antenna for UHF and ISM Systems***

Salman Zahid (National University of Sciences & Technology, Pakistan); Abdul Quddious (Frederick Research Center, Frederick University Nicosia, Cyprus & University of Cyprus, Pakistan); Farooq A. Tahir (National University of Sciences and Technology, Pakistan); Photos Vryonides (Frederick University Cyprus, Cyprus); Marco A. Antoniades (University of Cyprus, Cyprus); Symeon Nikolaou (Frederick Research Center, Cyprus)

A compact planar dual-band antenna for UHF and ISM bands is proposed. The antenna is fabricated on a 45 mm × 80 mm × 0.787 mm Rogers Duroid 5880 substrate and is intended for use in Wireless Power Transfer (WPT) and Power Harvesting (PH) systems. It covers the UHF band from 855-935 MHz making it a suitable antenna for UHF applications worldwide and the ISM band from 2.4-2.5 GHz. In order to exploit the power that can be harvested from the ambient environment, from entirely random directions, omni-directional behavior was intended. A prototype of the antenna has been fabricated and its S-parameter measurements, radiation pattern and gain simulations are presented.

12:10 ***Graphene-based Ultra-Wide Band Printed Bow-Tie Antenna for Remote Tracking***

Nicola Curreli (Italian Institute of Technology, Italy); Luca Schirru (National Istitute for Astrophysics - Astronomical Observatory of Cagliari, Italy); Luca Gagliani and Elisa Mantero (Istituto Italiano di Tecnologia, Italy); Giorgio Montisci (University of Cagliari, Italy); Marco Crepaldi (Istituto Italiano di Tecnologia, Italy); Alessandro Fanti and Giuseppe Mazzarella (University of Cagliari, Italy); Vittorio Pellegrini (Istituto Italiano di Tecnologia, Italy); Francesco Bonaccorso (Istituto Italiano di Tecnologia, Graphene Lab, Italy); Alberto Ansaldo (Istituto Italiano di Tecnologia, Italy)

Printed antennas are cheap, lightweight, easy to-fabricate with high precision, and adaptable to mass production. These features are desirable for both indoor and outdoor handheld UWB antenna applications. In this paper, we consider planar versions of a high performance ultra-wide band bow-tie antenna with omnidirectional radiation characteristics.

F_P09 Urban UWB Propag: F_P09 Urban and UWB propagation

TOP

Future Applications / Regular Session / Propagation

Room: Oral Sessions: S4-D - Bytom

Chairs: Jan M. Kelner (Military University of Technology, Poland), Kentaro Saito (Tokyo Institute of Technology, Japan)

10:50 ***A New Doppler Model for LMS Channel***

Sebastien Rougerie (CNES, France); Thierry Deloues (ONERA, France); Jonathan Israel (ONERA - The French Aerospace Lab, France)

The ITU-R Rec. P.681, which tackle Land Mobile Satellite (LMS) channel model between 1 to 20 GHz, provides reliable results from the statistical distribution point of view. However, the spectrum part of the model (i.e. Doppler model) is not completely relevant in the case of LMS links. For instance, a terrestrial model is assumed (Jakes model) and thus, second order statistics are not well reproduced by the ITU-R P681. In recent experimentations (previously published in EUCAP 2016), we investigated the Doppler spectrum shape. Based on these results, we propose in this paper a new Doppler spectrum model reliable for LMS application.

11:10 ***Extended Range Ultra-Wideband Millimeter-Wave Channel Sounder with Over-The-Air Calibration***

Robbert Schulpen, Dimitrios Konstantinou, Simon Rommel, Ulf Johannsen, Idelfonso Tafur Monroy and A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

In this paper, an ultra-wideband millimeter-wave channel sounder is introduced. The channel sounder, consisting of a Vector Network Analyzer and 1 km of fiber, can perform high resolution channel sounding over long distances. A wired response calibration is compared to an over-the-air calibration. It is shown that the over-the-air calibration of the channel sounder increases the dynamic range in the power-delay-profile by 14 dB compared to the wired response calibration.

11:30 ***Results of HD Radio VHF Mobile Reception Measurements in Dense Urban Regions***

Elizabeth Verdugo (PUC RIO, Brazil); Luiz da Silva Mello (CETUC-PUC-Rio & Inmetro, Brazil); Marta Pudwell Chaves de Almeida (Inmetro, Brazil)

This paper presents preliminary results of mobile propagation channel measurements at VHF frequencies, carried out in urban areas in São Paulo and Belo Horizonte, Brazil. Analysis of field strength measurements compared with predictions from ITU-R P. 1546 is included. As well as the obtaining of path loss exponent to characterize the propagation environment in each route. Large-scale and small-scale fading are statistically modelled, Chi-square hypothesis test and root mean square error are obtained to evaluate the statistical models. Finally, the reception quality was measured and the SNR threshold for good reception estimated.

11:50 ***Theoretical Path Loss Model for Suburban Fixed Wireless Access and Comparison Against 28 GHz Measurements***

Dmitry Chizhik (Nokia US, USA); Jinfeng Du (Nokia Bell Labs, USA); Rodolfo Feick (Universidad Técnica Federico Santa María, Chile); Reinaldo Valenzuela (Bell Labs, Alcatel-Lucent, USA)

A theoretical model for path gain in suburban Fixed Wireless Access links is found to be within 2.9 dB RMS error of measurements collected at 28 GHz, using a specialized narrowband channel sounder. The measurements were done with a 50o (10 dBi) transmit antenna on an exterior of a house, usually behind foliage, and a 10o (24 dBi) receive horn antenna at 3 m height, emulating a lamp post-mounted base station. The 10o base horn antenna was spun at speeds up to 300 rpm to capture azimuthal angular power distribution.

12:10 ***Efficiency of Antenna Array Tapering in Real Propagation Environment of Millimeter Wave System***

Kamil Bechta (Nokia Networks, Poland); Marcin Rybakowski (Nokia, Poland); Jinfeng Du (Nokia Bell Labs, USA)

In real propagation conditions the angular spread of radio channel reshapes the effective antenna pattern and impacts the efficiency of tapering method in comparison to nominal antenna pattern. Simulation results obtained for 3GPP UMa and UMi street canyon indicate that for effective antenna pattern the first side-lobe suppression level (SLL) can drop to 16 dB in case of LOS and even to 2 dB in case of NLOS, in comparison to SLL of 20 dB for nominal antenna pattern.

MT_P12 Propag Model: MT_P12 Propagation modelling and simulation

TOP

Methods & Tools / Regular Session / Propagation

Room: Oral Sessions: G1- Gniezno

Chairs: Rausley Adriano Amaral de Souza (National Institute of Telecommunications (INATEL), Brazil), Jacques Claverie (CREC St-Cyr & IETR, France)

10:50 ***Characterization of Frequency-Selective Massive MIMO Channels by Ray-Tracing***

Mehmet Mert Taygur (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

Frequency-selective channel characteristics and network performance in a single-cell urban massive MIMO scenario are investigated by ray-tracing simulations. The urban scenario consists of 64 single antenna users and 256 base station antennas. The channels between the users and the base station antennas are computed by ray-tracing simulations for a 10 MHz bandwidth with 1001 samples in the frequency domain. A frequency dependent Regularized Zero-Forcing (RZF) precoding scheme is utilized at the base station and the coherence bandwidth as well as the downlink data rate are calculated. In addition to the ray-tracing simulations, a second channel study according to the WINNER II statistical model is carried out and the results from both methods are compared. It is shown that achieving a coherence bandwidth on the order of MHz is possible for a typical small-cell deployment. Furthermore, it is demonstrated that the coherence bandwidth can be improved by utilizing a large number of transmitter antennas, even if the receivers are not equipped with channel equalizers.

11:10 ***Hollow Core Dielectric EBG Waveguide to Feed Microwave Ion Sources***

Giorgio Sebastiano Mauro (INFN-LNS, Italy); Andrea Locatelli (Università degli Studi di Brescia, Italy); Giuseppe Torrisi, Alberto Rovelli and Luigi Celona (INFN-LNS, Italy); Costantino De Angelis (Università degli Studi di Brescia, Italy); Gino Sorbello (University of Catania, Italy); Santo Gammino (INFN-LNS, Italy)

This paper presents a dielectric woodpile waveguide, operating at 18 GHz, that can sustains up to 50 kV DC voltages and can be used to feed and insulate microwave high voltage ion sources from grounded RF generators. The design carried out through MPB simulation software has been validated through Ansys HFSS full-wave simulation of the complete structure. The metallic-to-woodpile waveguide transition optimization gives a very low maximum insertion loss of 0.3 dB over a 3.75% bandwidth.

11:30 ***Vertical Refractivity Profiles Within the Marine Surface Boundary Layer***

Jacques Claverie (CREC St-Cyr & IETR, France)

Strong refraction effects are generally observed within The Marine Surface Boundary Layer. Thus, the performances of the electromagnetic sensors are greatly affected by the vertical refractivity profiles. The accurate prediction of these performances requires a very small vertical resolution. This results in a large amount of data to be stored. A very promising alternative is to describe the vertical profiles with simple analytical formulas without major deteriorations of the predicted propagation results.

11:50 ***A Novel Decision Fusion Periodogram-based Algorithm for Centralized Cooperative Spectrum Sensing Under Errors at the Report Channel***

Rausley Adriano Amaral de Souza (National Institute of Telecommunications (INATEL), Brazil); Lucas dos Santos Costa (National Institute of Telecommunications & Inatel, Brazil); Eduardo de Almeida (National Institute of Telecommunications, Brazil)

Spectrum sensing is the main task of cognitive radios (CRs) to detect idle bands for opportunistic use. In cooperative and centralized mode, CRs sense a target band and send data to a fusion center for a final decision upon its occupancy. It can be a raw data (soft decision) or local decision (hard decision) on the channel occupation state in each CR. Soft decision schemes typically achieve better performances but decision fusion is unbeatable in terms of traffic. This paper proposes a novel periodogram power spectral density estimate-based centralized cooperative spectrum sensing algorithm for decision fusion and makes a performance-traffic-trade-off with the circular folding cooperative power spectral density split cancellation soft decision algorithm, both under errors at the report channel. Results show that the proposed scheme is sensitive to errors but encoding can easily overcome it, still keeping the data traffic smaller than the quantized soft decision scheme with no coding. It can be concluded that a case-by-case analysis, performance versus data traffic, must be made in order to elect the best scheme for a given scenario.

12:10 ***Ground-to-Satellite Optical Link Turbulence Effects: Propagation Modelling & Transmit Diversity Performance***

Nikolaos Lyras (National Technical University of Athens, Greece); Charilaos Kourogiorgas (Science and Technology Facilities Council\RAL Space, United Kingdom (Great Britain)); Theodore Kapsis (School of Elec. & Com. Engineering, National Technical University of Athens, Greece); Athanasios D. Panagopoulos (National

Technical University of Athens, Greece)
In this paper, the ground-to-satellite optical links and especially optical feeder links are studied. A methodology for the derivation of received power statistics taking into considerations the phenomena that degrade the optical signal and especially the turbulence effects is reported. The methodology is validated in terms of the first order statistics with experimental data from the ARTEMIS bi-directional optical link campaign. Additionally, the small scale transmit diversity technique is employed and examined for the mitigation of atmospheric turbulence for uplink optical transmission. Simulated received power statistics for various transmit diversity scenarios are reported using the validated methodology.

L_P15 Earth-Space: L_P15 Earth-Space Propagation for land-mobile satellite and satellite navigation services

TOP

Localization & Connected Objects / Regular Session / Propagation
Room: Oral Sessions: G2- Opole
Chairs: Paweł R. Bajurko (Warsaw University of Technology, Poland), Michael Schönhuber (Joanneum Research, Austria)

10:50 ***Variability of the 0° Isotherm: Monthly Variations and Correlation with Ground Temperature***
Ana Benarroch (Universidad Politécnica de Madrid, Spain); Gustavo Siles (Universidad Privada Boliviana, Bolivia); Jose M Riera (Universidad Politécnica de Madrid, Spain)
Rain attenuation prediction models usually require rain height data that can be derived from the 0° isotherm height obtained as proposed in ITU-R recommendations and also from radiosonde measurements. Communication systems that make use of fade mitigation techniques require accurate information on the parameters that describe the variability of the propagation channel caused by various impairments. Statistical results on the variations of the 0° isotherm are presented in this paper focusing on the monthly variability and on the correlation with ground temperature.

11:10 ***Estimating Ambuiguity and Using Model Weight to Improve the Positioning Accuracyof a Stand-alone Receiver***
Tan Truong Ngoc (ENSTA Bretagne, France); Ali Khenchaf (ENSTA Bretagne & LAB-STICC UMR CNRS 6285, France); Fabrice Comblet (ENSTA Bretagne, France)
Basic positioning methods in GNSS receivers are based on code and carrier phase measurements. In this paper, the carrier phase measurements are considered. They are highly accurate, but limited with integer ambiguity, which is very important. This paper proposes an algorithm to resolve this problem. In addition, it shows the main factors that affect the accuracy of user position. To reduce the user's position errors, it eliminates the satellites with small evaluation angles and in the calculation, two weight models are proposed and applied. As compared to the positioning solution without weight, the positioning accuracy is improved by about 42.89 % with the SIGMA model and about 53.19 % with the exponential model.

11:30 ***Evaluting Process and Measurement Noise in Extended Kalman Filter for GNSS Position Accuracy***
Tan Truong Ngoc (ENSTA Bretagne, France); Ali Khenchaf (ENSTA Bretagne & LAB-STICC UMR CNRS 6285, France); Fabrice Comblet (ENSTA Bretagne, France)
Extended Kalman filter (EKF) is widely used in the dynamic systems under the assumption that the process and measurement noises are Gaussian distributed. It is well known that the covariance matrixes of process noise and measurement noise have a significant impact on the EKF's performance. To evaluate its impact on the estimation of user position, this paper proposes two models. The first model depends on the power spectral densities of speed noise, clock bias noise and frequency drift noise to estimate covariance matrix of process noise. The second model is an exponential model that depends on the satellite elevation angle to estimate covariance matrix of measurement noise.

11:50 ***Performance Evaluation of Ka- And Q-band Earth-Space Diversity Systems in Attica, Greece Using the Synthetic Storm Technique***
Athanasios D. Panagopoulos (National Technical University of Athens, Greece); Charilaos Kourogiorgas (Science and Technology Facilities Council\RAL Space, United Kingdom (Great Britain)); Apostolos Z. Papafragkakis (National Technical University of Athens, Greece)
The successful migration of satellite communication systems to higher frequency bands such as Ka- and Q-band necessitates the use of accurate channel statistics and propagation models. In this paper a statistical evaluation of rain attenuation in Attica, Greece is performed using emulated data obtained through the Synthetic Storm Technique (SST). The 2-years rainfall rate dataset available at NTUA for two locations is used as input to the SST to obtain rain attenuation time series. Both overall as well as diurnal, long-term statistical analysis is performed; additionally, site diversity scenarios are evaluated, investigating the impact of employing an attenuation threshold with hysteresis when switching between the ground stations. Finally, outage capacity statistics are investigated considering both conventional Single Input Single Output (SISO) and Single Input Multiple Output (SIMO) scenarios.

B_P02 Imag Inverse: B_P02 Imaging and Inverse Scattering

TOP

Biomedical / Regular Session / Propagation
Room: Oral Sessions: A2- Ustka
Chairs: Panagiotis Kosmas (King's College London, United Kingdom (Great Britain)), Ali Zamani (The University of Queensland, Australia)

10:50 ***Transmission-Based Radar-System for UWB Breast Cancer Imaging: A Study of Application to Patients***
Elham Norouzzadeh (K. N. Toosi University of Technology, Iran); Somayyeh Chamaani (K. N. Toosi Univerity, Iran); Jochen Moll (Goethe University Frankfurt am Main, Germany); Babak Bazrafshan and Frank Hübner (Goethe University Hospital Frankfurt am Main, Germany); Viktor Krozer (Goethe University of Frankfurt am Main, Germany); Thomas Vogl (Goethe University Hospital Frankfurt am Main, Germany)
Breast cancer detection at microwave frequencies benefits from the non-ionizing nature of microwave radiation and, thus, enables more frequent check-ups compared to X-ray mammography. Various algorithms exist in the literature to construct a radar image in which the highest intensity corresponds to the tumour location. A drawback of such a radar image is the missing physical interpretability. In addition, most of these image reconstruction techniques employ the effective permittivity of the breast tissue to form a map of scatterers in the generally heterogeneous breast tissue. Therefore, the quality of the tumor detection and localization in the final image is generally related to the accuracy of the estimated permittivity. In this paper, measurements from patients are presented based on a newly designed transmission-based ultra-wideband (UWB) radar system operating in the frequency range from 1 to 9GHz. Two algorithms for quantitative imaging are proposed which do not have the limitations of related techniques mentioned above. The first method shows a relative permittivty map of breast tissue in which the area with the highest permittivity can be recognized as malignant tissue. In the second method, signal attenuations in breast tissue are computed to localize the tumor as the location with the highest signal decay. Finally, those microwave images are compared to the corresponding X-ray images.

11:10 ***Three-Dimensional Electromagnetic Torso Imaging Using Reconfigurable Antennas***
Ali Zamani (The University of Queensland, Australia); Amin Darvazehban (University of Queensland, Australia); Sasan Ahdi Rezaeieh and Amin Abbosh (The University of Queensland, Australia)
Thoracic disorders, such as lung and liver cancer, and congestive heart failure are the major causes of chronic morbidity and mortality in the world. Electromagnetic imaging (EMI) is an emerging technique to diagnose those abnormalities in a fast and cost-effective way. In that regard, a portable human torso scanner, including a pattern reconfigurable metasurface antenna as a data acquisition device and a three-dimensional backpropagation method as an imaging algorithm are proposed. The utilized antenna consists of three rectangular microstrip-fed slot radiators to scan the torso in the bandwidth of 0.8–1.15 GHz. The image construction algorithm is then utilized to detect the locations of contrasts in dielectric properties of tissues, which are due to abnormal tissue. To that end, the electromagnetic power intensity inside the three-dimensional imaging region is estimated by combining a backpropagation technique with an interpolation method. The proposed method is successfully tested in measurements by detecting 20 mL accumulated water inside lungs of a human torso phantom as an emulation of pulmonary edema. The obtained results show that the proposed technique enables the accurate detection and localization of the target.

11:30 ***A 90°-Inclined Linearly Polarized Probe for Terahertz Mueller Imaging***
Xuexuan Ruan and Kung Bo Ng (City University of Hong Kong, Hong Kong); Huan Yi and Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China); Chi Hou Chan (City University of Hong Kong, Hong Kong)
A novel terahertz (THz) probe, consisting of a 90°-inclined linearly polarized (LP) component incorporated with a pyramidal-shaped TE10 mode rectangular open-ended waveguide (OEWG), is introduced in this paper. The pyramidal feed, located beneath the substrate, is made of brass plated with gold. The radiation component, placed on tip of the OEWG, is achieved by standard printed-circuit and plated-through-hole techniques. Measurement results demonstrate that the proposed probe possesses an impedance bandwidth (VSWR ≤ 2) of better than 18.5% from lower than 270 to higher than 325 GHz. In the impedance bandwidth, the measured gain is from 7.2 to 8.2 dBi and all radiation patterns are relatively symmetric with relatively small back radiation and cross-polarization levels. The proposed probe is a potential component for Mueller imaging at THz frequencies.

11:50 ***Kerker Effect with Hybridized Radiofrequency Resonators for Magnetic Resonance Imaging***
Marc Dubois (Institut Fresnel, France); Lisa Leroi (Neurospin - CEA Saclay - Paris-Saclay University, France); Alexandre Vignaud (Commissariat à l'Energie Atomique & NeuroSpin, France); Redha Abdeddaim (Aix Marseille University, France); Stefan Enoch (CNRS & Institut Fresnel, France)
A set of hybridized resonators is used to achieve efficient and tunable electromagnetic field control in the radiofrequency range. We demonstrate theoretically a full overlap between the electric dipolar and magnetic dipolar resonances of the meta atom. This interaction is precisely tuned to reach the so-called Kerker scattering conditions when illuminated by a plane wave. Finally, we investigate the meta atom response in the presence of a near field distributed source as the final goal of this study is to insert this element to control the radiofrequency electromagnetic field within a magnetic resonance imaging (MRI) head birdcage coil at 7 Tesla.

12:10 ***Enhanced Transcranial Ultrasonic Imaging Utilizing Dual Frequency Transducers***
Stamatis A. Amanatiadis (Aristotle University of Thessaloniki & Ormylia Foundation, Greece); Georgios Apostolidis, Chrysanthi Bekiari and Nikolaos V. Kantartzis (Aristotle University of Thessaloniki, Greece)
In the present work, the development of a dual frequency ultrasonic imaging method is proposed to assist the trancranial acoustic wave propagation for medical applications. This method depends on the significantly altered acoustic properties of the skull, compared to the soft brain tissues, mainly on the increased absorption coefficient. The latter leads in a differentiated acoustic wave

propagation at separate frequencies and the fusion of the acquired data provide an enhanced perception of the inner, to the skull, regions. The theoretical analysis is performed based on realistic human skull and brain tissue properties, while it is validated via an accurate numerical model, both in A-scan and B-scan modes.

Friday, April 5 12:30 - 13:30

Closing: Closing Ceremony TOP

/ Regular Session /

Room: Oral Sessions: S2 – Warszawa

Chairs: Pawel Kabacik (Wroclaw University of Science and Technology, Poland), Cyril Mangenot (Api-Space, France), Wlodzimierz Zieniutycz (Gdansk University of Technology, Poland)