Program for *2017 11th European Conference on Antennas and Propagation (EUCAP)*

Time	Oral Sessions: Auditorium Bordeaux	Oral Sessions: Auditorium Havane	Oral Sessions: Room 341	Oral Sessions: Room 342A	Oral Sessions: Room 342B	Oral Sessions: Room 343	Oral Sessions: Room 351	Oral Sessions: Room 352A	Oral Sessions: Room 352B	Oral Sessions: Room 353	Oral Sessions: Room 362/363	Poster Sessions: Corridor Neuilly	Poster Sessions: Corridor Paris	Poster Sessions: Corridor Top	WG Meetings & Workshops: Room 313/314	WG Meetings & WorkShops: Room 315
Monday, March 20																
09:00-10:00	*Opening Session*															
10:00-10:40	*IK_01 Invited Keynote 1*															
11:10-12:30	*IK_02 Invited Keynote 2&3*															
14:00-18:30	*Sp_P01 Tropospheric Propagation for Space Applications I*	*CS31 New Trends in Reflectarrays and Transmitarrays*	*CS19 High-Data Rate Wireless Connectivity for Smart Rail Mobility*	*C_P01 Millimeter Wave Radio Channels I*	*B_A01 Antennas for Biomedical Applications*	*H_A02 Mm-Wave Antennas for High Data Rate I*	*CS20 In Memory of Prof. Per Simon Kildal (Dedicated session)*	*R_M01 RCS Measurements*	*CS24 Measurements and Simulations in Channel Modelling in Wireless Body Area Networks (COST CA15104 IRACON)*	*MT_A01 Integral Equations*	*CS01 A Century After Tesla: How Far Have We Come With Wireless Power Transfer ?*					
16:30-18:30			*CS08 Advances on Transformation Electromagnetics Based Antennas*	*C_M02 Measurement Topics*	*B_P03 Biological Propagation Measurements*	*CS23 Massive MIMO Antenna Technologies and Interference Mitigation Techniques for 5G Networks in the Frequency Bands above 6 GHz*		*R_A02 Antennas for Imaging*	*L_A04 Wireless Power Transmission and Harvesting I*	*MT_A02 Computation Techniques*	*CS22 Innovative Antennas for TT&C and PDTM Satellite Links*				*WG_01 Propagation*	
Tuesday, March 21																
08:40-12:30		*CS02 Additive Manufacturing for Antenna and RF Components*	*W_A01 Adaptive & Reconfigurable Antennas for Wireless Networks*	*C_M01 MIMO measurements*	*CS05 Advances in Electromagnetic Diagnostics and Biomedical Sensors*	*CS25 Mm- and THz-wave Propagation Measurements and Modelling for Ultra-high Data Rate Communications (COST CA15104 IRACON)*	*CS29 New Antenna Systems Involving Application of Metamaterials and Metasurfaces (IET)*	*R_A01 Mm-Wave Radar Antennas*	*CS45 Smart Beamforming in Far-Field Wireless Power Transmission*	*CS04 Advanced Statistical Methods and Tools in Applied Electromagnetism*	*F_A04 Submillimeter-wave & Terahertz antenna*				*IWS_01: How to design a matching circuit that matches with the measurements?*	
10:50-12:30			*W_A02 Arrays Antenna for Wireless Networks*					*R_P04 RCS Models*	*L_A02 Wireless Power Transmission and Harvesting II*		*F_A05 Adaptive & Reconfigurable Antennas for Future Applications*				*WG_02 Small Antennas*	*IWS_05: ANSYS Workshop: Antenna Placement and Coupling*
13:30-16:20												*Poster_01*	*Poster_02*		*WG_03 Measurement EurAAP WG*	*SWS_01: Advances in Commercial Electromagnetic Simulation Tools*
15:00-16:20	*Inv_01 Invited Session 1*	*Inv_02 Invited Session 2*													*WG_03 AMTA Europe Meeting*	
16:50-18:30	*Sp_A01 Frequency & Polarization Selective Surfaces*	*CS11 Current Challenges in Low Frequency Antenna System Verification*	*W_A04 Mm-Wave Antennas for Wireless Networks*	*C_P05 Time-Varying Radio Channels*	*CS32 OPTIC BIOEM and other approaches for electropulsation in medicine and biology*	*CS47 THz Antennas and Subsystems for High Data Rate Communication Links*	*CS18 Glide Symmetry Surfaces for mm and Sub-mm Lens Antennas*	*R_P01 Radar Imaging*	*CS37 Propagation in Aeronautics*	*CS43 Signal Processing Techniques to Improve Antenna Characterization Procedures (AMTA/EurAAP)*	*CS46 The Alphasat Aldo Paraboni Scientific Experiment: Results and Developments after 3 Years of Operations*					*IWS_03: New Over-the-Air Measurement Methods and Design Considerations for Millimeter Wave Antenna Arrays*
Wednesday, March 22																
08:40-12:30		*CS17 From Pioneering Antenna Contributions to Industrial Applications*	*CS44 Small Antennas: From Theory to Practice*	*C_P03 Urban Propagation*	*B_P01 Biomedical Imaging*	*CS48 THz Wireless Communications: from Components to Systems*	*CS27 Mm-wave GAP Waveguide Technology*	*CS13 Electromagnetic Methods for Direct and Inverse Scattering Involving Stratified Media*	*L_A03 MIMO & Smart Antennas*	*CS10 Characteristic Mode Analysis for Platform-Mounted Antenna Design*	*Sp_P02 Tropospheric Propagation for Space Applications II*					*SWS_05: Revision and Changes to the IEEE 149 Standard on Antenna Measurements (AMTA Workshop)*
10:50-12:30				*C_P04 Millimeter Wave Radio Channels II*	*B_M01 Biological Measurements*				*L_P01 Localization & Ranging*	*B_P02 Body-Centric Propagation*	*Sp_A05 Antenna-System for Space Applications*					
13:30-16:20												*Poster_03*	*Poster_04*	*Poster_05*		*SWS_03:*
															IWS_04: Efficient	

15:00-16:20	*Inv_03 Invited Session 3*	*Inv_04 Invited Session 4*													*simulation of antenna placement on different platforms (Aeronautical, Automotive, Naval,...)*	*Nanotechnology Applications of Antennas and Wireless Sensing*
16:50-18:30	*Sp_A03 Reflectarrays and Transmitarrays*	*CS21 Innovative Antenna Architectures for Very High Throughput Satellite (VHTS) Systems*	*W_P01 Vehicular channels*	*C_P02 Indoor Propagation*	*CS50 Wireless Sensors for Medical Applications: from Wearables to Implants*	*H_A04 Mm-Wave Antennas for High Data Rate II*	*CS40 Radiation Control Techniques for Small Antennas*	*R_P02 Radar Systems*	*L_A01 Antenna sensors*	*MT_M01 Advances in Test Range Design*	*F_A02 MetaSurfaces I*				*WG_05 ESoA*	

Thursday, March 23

08:40-12:30		*CS41 Recent Developments in Antenna Technologies for Emerging Satellite Systems*	*CS30 New Trends in Characteristic Modes Research*	*C_A02 Small and Compact Antennas*	*CS16 European Academic and Industrial Advances in Microwave Medical Technologies (COST TD1301 MiMed)*	*CS26 Mm-wave Antenna Systems for Future Broadband Communication Networks*	*F_A06 Nano Antennas*	*CS15 Emerging Strategies for the Synthesis of Innovative Array-Antenna Architectures*	*L_M02 Near-Field Measurements*	*CS39 Propagation Channels for Wide Sense Vehicle to X Communications*	*CS42 Satellite and Aerospace Antenna Measurements (AMTA/EurAAP)*					*IWS_02: CST Workshop - Advanced Antenna System Simulation*
10:50-12:30				*C_A01 Wideband Antennas*			*F_A07 Antenna theory*		*L_M01 MIMO & OTA measurements*							
13:30-16:20												*Poster_06*	*Poster_07*	*Poster_Awards*	*SWS_04: Radiofrequency coils for Magnetic Resonance Imaging*	*SWS_02_I: Frontiers in Propagation and Wireless Channel Modeling*
15:00-16:20	*Inv_05 Invited Session 5*	*Inv_06 Invited Session 6*														
16:50-18:30	*Sp_A04 MetaSurfaces for Space Applications*	*CS14 Electronically Scanned SatCom Terminal Antennas: State-of-the-Art and New Developments*	*W_A03 3D Printed Antennas*	*CS36 Practical Applications of Characteristic Mode Theory to Antenna Design*	*CS06 Advances in Microwave Breast Cancer Diagnosis and Treatment (COST TD1301 MiMed)*	*H_A01 Mm-Wave Antennas for High Data Rate III*	*F_P01 Numerical Radio Channel Modeling*	*CS38 Propagation Aspects in Remote Sensing*	*L_A05 Wire & Loop Antennas*	*R_P03 Imaging and Inverse Scattering*	*F_M03 Material Measurements*					

Friday, March 24

08:40-11:50	*Sp_A02 Reflector & Lenses for Space Applications*		*F_A03 Antennas for future Applications*	*CS33 OTA Characterization of Antennas and Devices from RIMP to Random-LOS and all in Between*	*CS12 Developments in Electromagnetic Medical Interventions (COST TD1301 MiMed and COST BM1309 EMF-MED)*	*H_A03 Array Antennas for Future Applications*	*CS03 Addressing Radio Frequency Test Challenges in Diverse Environments (AMTA/EurAAP)*	*CS28 Near Field Antenna Measurement Techniques (AMTA/EurAAP)*	*CS09 Antenna for IoT Applications*	*R_A03 Defense and Security Applications*	*CS34 Phased Arrays for Radio Astronomy*					
10:30-11:50			*F_A08 Leaky-Wave Antennas*			*F_P02 Other Propagation Topics*	*F_A01 Metasurfaces II*		*CS49 Wireless Chipless Sensors*	*CS35 Polarimetric Radar Signal Processing and RCS Analysis*						
12:00-13:00	*Closing Ceremony*															

Monday, March 20

Monday, March 20, 09:00 - 10:00

Opening Session

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Cyril Mangenot (European Space Agency, The Netherlands), Alain Sibille (Telecom ParisTech, France)

Monday, March 20, 10:00 - 10:40

IK_01 Invited Keynote 1

Room: Oral Sessions: Auditorium Bordeaux

Chair: Cyril Mangenot (European Space Agency, The Netherlands)

10:00 *A Whirlwind of Innovation in Space Technology*

Jean-Claude Souyris (CNES, France)

This presentation will primarily turn the spotlight on the hot topics of the moment in Space activities: the arrival of new players, mainly from the digital world where young millionaires discover a passion for space and are receptive to the idea that space can be conquered by private entrepreneurs; the emergence of large scale satellite constellations; the enthusiasm for nanosatellites enabling the academic world to nurture its training and research ambition; the growing volumes of satellite data, and the development of space applications fuelled by the spectacular transition to the digital economy. We will then address some of the key technologies for the Space of tomorrow (including those in the field of RF technics, antennas, and propagation), that need to be mastered in order to adapt to the foreseen changes. The talk will finally be illustrated by an example of innovation management in a timeline of 25 years in the field Earth Observation based on RF and antenna techniques (radar altimetry) for ocean observation and water management.

Monday, March 20, 11:10 - 12:30

IK_02 Invited Keynote 2&3

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Anja K. Skrivervik (EPFL, Switzerland), J (Yiannis) Vardaxoglou (Loughborough University, United Kingdom)

11:10 *Human-Centric Antennas*

Koichi Ito (Chiba University, Japan)

Recently, wearable wireless devices have been widely used in our daily life. Also, implantable wireless devices have been developed and become available for various monitoring as well as identification systems. Unlike conventional wireless devices, wearable or implantable devices are used on or in the human body. In this sense, body-centric wireless communications (BCWCs) have become a very active area of research. On the other hand, radio-frequency or microwave medical devices used for cancer treatment and surgical operation have completely different functions. However, they are used on or in the human body. In terms of antennas installed inside the devices, such medical devices have lots of similarities to BCWCs. To design properly and to make the best use of specific antennas for different wireless devices, it is important to treat them as human-centric antennas. In general, the problem of an antenna placed on or in the human body can be treated as a so-called "boundary value problem" where the human body is considered as a lossy medium. However, in reality and simplicity, an individual case is treated appropriately in a specific manner by numerical simulation such as the FDTD technique. The paper introduces a few examples of wearable antennas as well as implantable antennas developed and tested in our laboratory. In addition, the paper describes some challenges of human-centric antennas.

11:50 *Affordable Phased-Arrays for 5G and SATCOM: Ending the Marconi Era*

Gabriel Rebeiz (UCSD, USA)

This talk will present the latest work on microwave and mm-wave phased arrays at UCSD and in the world. The talk shows that one can build affordable phased arrays using low-cost silicon-RFICs (RF integrated circuits), and these phased-arrays are now being considered to replace the movable reflector for satellite communications on airplanes, ships and moving platforms. The silicon-based phased-arrays are also being considered for terrestrial 5G communication systems, to be employed first to replace the "last mile" for internet and video delivery to homes, and then for high-speed links between base-stations and a mobile user. In this context, phased-array systems

achieving Gbps at 300 meters and 1000 meters will be presented. It will be shown that low-cost phased-arrays have changed the way we think about our future communication systems from SATCOM to 5G.

Monday, March 20, 14:00 - 18:30

TOP

Sp_P01 Tropospheric Propagation for Space Applications I

Space / Regular Session / Propagation
Room: Oral Sessions: Auditorium Bordeaux
Chairs: Joel Lemorton (ONERA, France), Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium)

14:00 ***Alphasat Propagation Experiment in Madrid: Results on Excess and Total Attenuation***
Jose M Riera and Domingo Pimienta-del-Valle (Universidad Politécnica de Madrid, Spain); Pedro Garcia-del-Pino (Universidad Politecnica de Madrid, Spain); Gustavo Siles (Agencia Boliviana Espacial, Bolivia); Ana Benarroch (Universidad Politécnica de Madrid, Spain)
Universidad Politécnica de Madrid (UPM) is participating in the Alphasat propagation experiment by measuring the copolar level of the Q-Band beacon at 39.4 GHz since April 2014. In this paper the results of the first two complete years of measurements (until March 2016) are presented with regards to excess and total attenuation. The reference level is calculated on an event-by-event basis in the first case, and obtained from GNSS-based gas attenuation in the second one. The results reflect the variability of the meteorological conditions in the climate of Madrid, with strong differences among the months of the year and between the two years, reinforcing the need of having long-term propagation experiments to capture all the variability of the propagation effects.

14:20 ***Alphasat Q/V-Band Propagation: a Heuristic Approach for Rainy Events Detection***
Ada Vittoria Bosisio (CNR-IEIIT c/o Politecnico di Milano, Italy); Roberto Nebuloni (Ieiit - Cnr, Italy); Carlo Riva and Angelo Sileo (Politecnico di Milano, Italy)
A heuristic algorithm based on two threshold values of a scalar indicator, given by the ratio of the brightness temperatures measured by a ground-based radiometer at 31.4 and 23.8 GHz, is employed to detect the presence, if any, of rain events along the Earth to satellite propagation path in the framework of the Alphasat Aldo Paraboni Propagation Experiment. The promising preliminary results have single out the need of a finer identification of the initial and final time of the event toward the prediction of the rain contribution to the total tropospheric attenuation.

14:40 ***Spectral Coexistence of GEO and MEO Satellite Communication Networks: Differential Total Atmospheric Attenuation Statistics***
Charilaos Kourogiorgas and Athanasios D. Panagopoulos (National Technical University of Athens, Greece)
In this paper, the differential total atmospheric attenuation and differential total losses are investigated in the case of spectral co-existence of GEO and MEO constellation satellite communication systems. In order to use larger bandwidth in the next generation satellite communication systems, many radio systems may share the same spectrum. Due to the high interest on MEO constellation systems to increase the data rates, the coexistence between MEO/GEO satellite communication systems could lead to higher bandwidth for both systems. Therefore, the intersystem interference between MEO and GEO communication systems should be investigated for the reliable design of both satellite networks. Therefore it is necessary to develop an accurate channel model for generating total atmospheric attenuation time series. The synthesizer is based on SDESs and incorporates the spatial correlation of all the atmospheric attenuation factors. From the results, it is found that high intersystem interference is induced due to propagation phenomena.

15:00 ***Clear-Air Scintillation Analysis of Q-Band Alphasat Link at Spino d'Adda Using Radiosounding Data***
Augusto Marziani (Sapienza University of Rome, Italy); Fernando Consalvi (FUB, Italy); Carlo Riva (Politecnico di Milano, Italy); Elio Restuccia (Istituto Superiore delle Comunicazione e delle Tecnologie dell'Informazione - MISE, Italy); Frank S. Marzano (Sapienza University of Rome, Italy)
Scintillations affect the propagated signal with an unwanted aleatory oscillation at the receiver. A first analysis of data acquired from Alphasat Q-band receiver station, located in Spino d'Adda (Italy), is performed. Correlation between meteorological measurements at the ground and measured scintillation from the Q-band beacon receiver (i.e., fluctuation of the received electromagnetic field) is investigated. Radiosounding data from north Italy station of "Milano Linate" have been collected for the entire year 2015 and used to calculate the refractive index structure constant. Subsequently the amplitude scintillation variance is derived through the use of the Rytov model on the slant path. Results obtained using the scintillation model are compared with measured data from Alphasat beacon receiver, investigating the statistical correlation in clear air condition between simulated and measured data.

15:20 ***Evaluation of Recent Prediction Models Using a Long-Term Database of Rainfall Rate Data***
Pedro Garcia-del-Pino (Universidad Politecnica de Madrid, Spain); Domingo Pimienta-del-Valle, Ana Benarroch and Jose M Riera (Universidad Politécnica de Madrid, Spain)
The performance of both a recent rainfall rate model and the inter-annual variability prediction method proposed by

the International Telecommunication Union has been assessed taking advantage of the availability of 16 years of rain gauge data. The above rainfall rate model produces as well monthly rainfall rate distributions that have been compared with the experimental monthly distributions achieving good results. The procedure proposed in the ITU variability prediction method has been adapted to test its usefulness to estimate monthly and seasonal variability. In some cases, fair agreement has been found between estimated and experimental variability.

15:40 ***Tropospheric Scintillation Spectra and Transversal Wind Speed for Satellite Links at Very Low Elevation Angles***

Martin Rytir (Norwegian Defence Research Establishment (FFI), Norway); Carlo Riva (Politecnico di Milano, Italy); Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium); Terje Tjelta (Telenor, Norway)

Simultaneous measurements of tropospheric scintillation on three different satellite beacons at Ka-band are analyzed. The links have elevation angles of 3.3, 21.2 and 22 degrees. Corner frequency of scintillation is used to calculate the transverse wind speed on each of the links and this is compared with the predictions from a numerical weather model. Results for the two links with higher elevation angle show good agreement with each other as well as with the model data. For the link with elevation angle of 3.3 degrees good match with model data is achieved only when theory applicable for outer scale of turbulence smaller than the Fresnel zone is used. Significant changes in scintillation corner frequency during rain events are also observed for the 3.3 degree link. The results indicate that scintillation at very low elevation angles can be composed of different phenomena, leading among others, to different frequency dependence.

16:00 Coffee Break

16:30 ***Considerations of Rain Cell Size and Statistics for Attenuation Prediction Models***

George Brost (Air Force Research Laboratory, USA); Kevin Magde (AFRL, USA)

Physical-based rain attenuation prediction models conventionally assume a deterministic dependence of rain cell size on rainfall rate and uniaxial structure. This study examined the impact of these assumptions on attenuation predictions. In comparison with model predictions that apply an exponential distribution of cell sizes, the deterministic models exhibited a small cell size effect in which the attenuation exceedance probability was clamped due to the limited path through the rain cell. This resulted in an under- estimation of attenuation in many cases. A biaxial rain-cell attenuation prediction capability was developed to model observed biaxial rain cell shapes and orientational distributions.

16:50 ***Depolarization Effects on Satellite Links Evaluated Using Five-year Experimental Drop Size Distributions***

Jose Garcia-Rubia (Virginia International University, USA); Jose M Riera and Ana Benarroch (Universidad Politécnica de Madrid, Spain); Pedro Garcia-del-Pino (Universidad Politecnica de Madrid, Spain)

Drop Size Distributions (DSDs) measured with an optical disdrometer in Madrid during 5 years are used to derive the copolar attenuation (CPA) and cross polarization discrimination (XPD) at 19.7 and 39.4 GHz. A full wave Method of Moments (MoM) is utilized to calculate specific attenuation and phase rotation through a realistic scattering raindrop model for large raindrops. The best-fit parameters are compared with those given in the ITU-R Recommendation P.618-12. Significant differences are observed for vertical and horizontal polarizations at 19.7 and 39.4 GHz. In this paper, yearly variability of XPD and fitting parameters are presented.

17:10 ***Preliminary Analysis of Atmospheric Attenuation and Sky Brightness Temperature at Deep-Space Antenna Site of Cebreros for Communications in Ka Band***

Andrea Giannini and Mattia Mercolino (European Space Agency, Germany); Alberto Graziani (Université Catholique de Louvain, Belgium); Antonio Martellucci (European Space Agency, The Netherlands)

The move towards higher frequency bands like 26GHz or 32GHz for scientific satellite data downlinks calls for the need to better characterise the atmosphere at the sites where ground antennas are located. For this reason ESA is undertaking the deployment of microwave radiometers at its Deep Space station locations. This paper reports the results of the first two years of site characterisation at the ESA Deep Space antenna 2 located in Cebreros, Spain.

17:30 ***Performance of Equatorial Multiple-Site Diversity Systems Evaluated from Rain Rate Time Series***

Michele D'Amico and Andrea Manzoni (Politecnico di Milano, Italy); Boris Ramos (Escuela Superior Politécnica del Litoral (ESPOL), Ecuador); José Luis Santos (Escuela Superior Politécnica del Litoral, Ecuador)

For the last decades satellite communication systems have been moving towards higher and higher frequencies; rain attenuation along the Earth-satellite path can be an important limiting factor for the system availability, especially in tropical regions where rain events can be particularly intense. One of the possible countermeasures is site diversity. In this paper we evaluate the performance of small-scale, multiple-site diversity systems, through simulations performed on rain-rate time series gathered by four rain gauges located in the equatorial city of Guayaquil, Ecuador. The results show a considerable improvement in terms of performance of the system.

17:50 ***Optical Satellite Links Channel Modeling: Time Series Generator and Mitigation Techniques Evaluation***

Nikolaos Lyras, Charilaos Kourogiorgas and Athanasios D. Panagopoulos (National Technical University of Athens, Greece)

The employment of optical frequencies in satellite communication systems has been proposed in order to cover the huge needs for capacity in the next decade. The reliable design and the prediction of the performance of optical satellite links need accurate channel modeling in the form of time series generators. Considering cloud free line- of-

sight (CFLOS) satellite links, turbulence effects on the received signal contain the dominant fading mechanism. In this paper a methodology for generating time series of irradiance due to turbulence for optical satellite uplink scenario is presented. The time series generator takes advantage of the use of Stochastic Differential Equations SDEs driven by Brownian motion. The methodology is applied for several hypothetical links in Greece for the generation of first order statistics of received power. Moreover small scale and large scale diversity techniques are evaluated for the mitigation of turbulence effects.

18:10 ***An Advanced Propagation Tool for Satellite ATM and Aeronautical Communications***

Joel Lemorton (ONERA, France); Jonathan Israel (ONERA - The French Aerospace Lab, France); Thomas Jost and Michael Walter (German Aerospace Center (DLR), Germany); Alberto Graziani (Université Catholique de Louvain, Belgium); Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium); Nicolas Floury (ESA, The Netherlands)

The objective of this paper is to present the development of a new software tool for the analysis of propagation effects on satellite-to-aircraft communications, valid for frequencies between VHF and Ka-band, and which takes into account the following technical/scientific issues: • modifications induced on the aircraft antenna pattern by its installation on the platform (due to interaction with the structural elements of the platform) and corresponding short delay additional multipaths, including in the case of moving elements (e.g. helicopter blades), • geometry of the trajectory and aircraft dynamics during movements including attitude, • surface scattering effects for sea and ground surfaces, including vegetation layers, • atmospheric effects due to troposphere at different altitudes and ionosphere.

TOP

CS31 New Trends in Reflectarrays and Transmitarrays

Space / Convened Session / Antennas

Room: Oral Sessions: Auditorium Havane

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

14:00 ***Dual-Band Dual-Polarized Transmitarrays At Ka-band***

Trung Kien Pham (University of Rennes 1 & IETR, France); Ronan Sauleau (University of Rennes 1, France); Erwan Fourn (INSA of Rennes & IETR, France); Fatimata Diaby (Université Grenoble-Alpes & CEA, France); Antonio Clemente (CEA-LETI Minatec, France); Laurent Dussopt (CEA, LETI, Minatec, France)

Transmitarray antennas with dual-band and dual-polarization capabilities are studied here numerically. The antennas are designed based on linearly-polarized unit-cells working at Ka-band for satellite applications. The unit-cells include two printed patches and a connecting via; a 180° phase shift is obtained by rotating one of the patches. The dual-band property is achieved by interleaving unit-cells dedicated to each band, and two different polarizations in each band. The numerical results demonstrate the working principles of dual-band dual-polarized transmitarrays.

14:20 ***Investigation on Double Layer Conformal Reflectarray Antenna***

Michele Beccaria, Paola Pirinoli and Mario Orefice (Politecnico di Torino, Italy)

In this communication the possibility of enhancing the radiation performances of a printed Convex Conformal Reflectarray is investigated. In particular, results on the effect of the use of dual layer stacked patches as re-radiating elements are shown.

14:40 ***A Dual-CP Reflectarray Unit Cell for Realizing Independently Controlled Beams for Space Applications***

Mehdi Hosseini and Sean V Hum (University of Toronto, Canada)

The paper presents a dual circular polarization unit cell for realizing a reflectarray that synthesizes two independent patterns based on the polarization of the incident field. To this end, a thin polarizer, which converts incident circularly polarized (CP) waves into orthogonal linearly polarized (LP) waves, is cascaded with a dual-linear-polarization (DLP) reflectarray. The reflectarray then applies the required reflection phases to the LP waves. The proposed antenna system is structured by placing the polarizer adjacent to the DLP reflectarray. Numerical simulations are arranged to assess the performance and ability of a 20 GHz unit cell design in providing high polarization purity and independent reflection phases for orthogonal CP waves. Enclosing 4×4 polarizer cells as small as 0.14λ×0.14λ, the unit cell features an overall thickness of ~1λ and lateral dimensions of 0.55λ×0.55λ.

15:00 ***High-Performance Curved Contoured Beam Reflectarrays with Reusable Surface for Multiple Coverages***

Min Zhou and Stig Sørensen (TICRA, Denmark); Rolf Jørgensen (Ticra, Denmark); Oscar Borries and Erik Jørgensen (TICRA, Denmark); Giovanni Toso (European Space Agency, The Netherlands)

An investigation of curved contoured beam reflectarrays with reusable surface for multiple coverages is presented. The main advantage of curved reflectarrays over shaped reflectors is that they allow the possibility of reusing a standard parabolic mold for multiple missions. To demonstrate this, two curved reflectarrays are designed using the direct optimization technique to fulfill the requirements of two contoured beam missions in both transmit and receive frequency bands for dual linear polarization. The two reflectarrays use the same curved surface, f/D, dimension, and feed, and by changing the reflectarray element pattern, two completely different coverages can be produced while maintaining a performance that is comparable to that of the shaped reflector.

15:20 ***Dual Reflectarray Antennas for Contoured Beam and Beam Scanning Applications***

Carolina Tienda (Airbus Defence and Space, United Kingdom); Jose A. Encinar and Mariano Barba (Universidad Politecnica de Madrid, Spain); Manuel Arrebola (Universidad de Oviedo, Spain)

Two dual reflectarray antennas able to provide an European coverage and beam scanning over 8º respectively have been presented. An accurate technique has been proposed for the analysis of dual-reflectarray antennas, which takes into account the angle of incidence of the field impinging on main reflectarray cells. Two 50-cm antenna demonstrators with the same geometry have been manufactured and measured in a compact range. The measured radiation patterns for the contoured beam antenna are in good concordance with the simulations and practically fulfill the coverage requirements with a cross-polar discrimination better than 25 dB in the frequency band 12.975 GHZ- 14.25 GHz. The measured radiation patterns of the beam scanning antenna are in good agreement with the simulations for transmit and receive frequency bands in Ku-band with a cross-polar discrimination better than 30 dB within a scanning range of +4°.

15:40 ***Dual-Polarization Reflectarray in Ku-band Based on Two Layers of Dipole-Arrays for a Transmit-Receive Satellite Antenna with South American Coverage***

Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Rafael Florencio (Universidad de Sevilla, Spain); Manuel Arrebola (Universidad de Oviedo, Spain); Miguel Salas (Technical University of Madrid, Spain); Mariano Barba (Universidad Politecnica de Madrid, Spain); Rafael R. Boix (University of Seville, Spain); Giovanni Toso (European Space Agency, The Netherlands)

A 1.1-m reflectarray antenna has been designed, manufactured and tested to fulfil the requirements of a satellite antenna in Ku-band to provide a South American coverage in Tx and Rx. The reflectarray cells consist of four dipoles for each polarization in two dielectric layers, which were selected because of their simplicity and high performance. The dipole dimensions are optimized in all the reflectarray cells to accomplish the prescribed radiation patterns, by iteratively calling an analysis routine based on MoM-SD and local periodicity. The measured radiation patterns of the manufactured antenna have been satisfactorily compared with simulations and with a 3-layer reflectarray previously designed for the same mission.

16:00 Coffee Break

16:30 ***Advanced Learning-Based Approaches for Reflectarrays Design***

Lorenza Tenuti (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Daniele Bresciani (Thales Alenia Space, France); Andrea Massa (University of Trento, Italy)

The problem of efficiently and effectively compute the response (i.e., reflection coefficients) of next-generation reflectarray elements with wide number of degrees-of-freedom is addressed in this work. Towards this end, a machine learning- based approach based on advanced Kriging strategies is exploited (instead of classical full-wave solvers) in order to predict the response of complex unit cells of interest for the design of high-performance reflectarrays. Preliminary numerical results aimed at comparing the accuracy and efficiency of the proposed methodology with respect to standard full-wave approaches are illustrated.

16:50 ***Exploiting Non-Radiating Currents in Reflectarray Antenna Design***

Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Angelo Gelmini (ELEDIA Research Center, University of Trento, Italy); Marco Salucci (ELEDIA Research Center, Italy); Daniele Bresciani (Thales Alenia Space, France); Andrea Massa (University of Trento, Italy)

A new paradigm for the design of reflectarrays is introduced. The proposed methodology allows the designer to specify constraints/simplifications on the antenna surface current distribution thanks to an innovative exploitation the non-radiating (NR) component, which is regarded a powerful additional degree-of-freedom (DoF) in the synthesis process. An illustrative example is presented, aimed at nulling the current density within a selected sub-region of a planar reflectarray by means of a suitable particle swarm optimization (PSO) of the NR contribution. The effectiveness and the potentialities of the proposed feasible source synthesis methodology are verified by means of a numerical benchmark, opening the doors to a completely new horizon in the design of next generation reflectarrays.

17:10 ***Demonstration of a High-Efficiency Reflectarray Antenna at 1 THz Based on Dielectric Resonators***

Eduardo Carrasco (Foundation for Research on Information Technologies in Society, IT'IS, Switzerland); Daniel Headland (The University of Adelaide, Australia); Shruti Nirantar (RMIT University, Australia); Withawat Withayachumnankul (The University of Adelaide, Australia); Philipp Gutruf (Northwestern University & Rogers Research Group, USA); James Schwarz (RMIT University, Australia); Derek Abbott (The University of Adelaide, Australia); Madhu Bhaskaran and Sharath Sriram (RMIT University, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

A reflectarray antenna composed of more than 87000 single-crystal silicon resonators on a gold ground plane is experimentally demonstrated to achieve efficient beam focusing at 1 THz. The functionality of the reflectarray as a collimator is also verified by the principle of antenna reciprocity. Because of the low-loss and nondispersive nature of high-resistivity silicon in the submillimeter regime, the losses of the reflectarray are negligible, a very desirable feature at such frequencies. Reflectarrays based on dielectric resonator antennas (DRA) have been relatively unexplored in the terahertz range, mainly because of the challenging fabrication process.

17:30 ***Single-Layer Reflectarrays - Past, Present and Future***

Y. Jay Guo and Peiyuan Qin (University of Technology, Sydney, Australia)

This paper presents an overview of the advances in single layer reflectarrays. In particular, it reports the progress in wideband reflectarrays and reconfigurable reflectarrays.

17:50 ***Estimation of Frequency Characteristics of Reflectarray by Introducing Aberration Theory***

Shigeru Makino, Kento Takeshima, Tetsuo Hirota, Keisuke Noguchi and Kenji Itoh (Kanazawa Institute of Technology, Japan); Takeshi Shiode and Michio Takikawa (Mitsubishi Electric Corporation, Japan)

In this paper, aberration theory will be introduced to estimate the frequency characteristics of reflectarrays. By introducing aberration theory, the mechanisms of the frequency characteristics of the beam squint and the phase errors on the aperture will be qualitatively clarified. The validity will be quantitatively verified by simulations.

18:10 ***Improving Convergence in Crosspolar Optimization of Reflectarray Antennas***

Daniel R. Prado (Universidad de Oviedo & Group of Signal Theory and Communications, Spain); Manuel Arrebola, Marcos R. Pino and Fernando Las-Heras (Universidad de Oviedo, Spain)

Two techniques are compared for the crosspolar optimization of reflectarray antennas using a full-wave analysis technique based on local periodicity directly in the optimization process within acceptable computing time. The first one is based on the Levenberg-Marquardt Algorithm (LMA) while the second technique is based on the generalized Intersection Approach framework using the LMA as backward projector. As full-wave analysis technique, a spectral domain Method of Moments based on local periodicity is employed. Two test cases are provided to show the capabilities and limitations of the techniques. The optimization is carried out in different computers to assess their scalability properties. In addition, the convergence of both techniques is compared in terms of number of iterations and results achieved.

Monday, March 20, 14:00 - 16:00

TOP

CS19 High-Data Rate Wireless Connectivity for Smart Rail Mobility

Wireless Networks / Convened Session / Propagation

Oral Sessions: Room 341

Chairs: Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain), Juan Moreno (Metro de Madrid S.A. & Universidad Politécnica de Madrid, Spain)

14:00 ***How to Provide Ultrabroadband Services in Train to Ground Communications Today***

Ron Porter and Nir Hayzler (RADWIN, Israel); Carlos Martinez (RADWIN, Spain)

The Transportation environment is a varied vertical that refers to various metro & train scenarios (both under and above ground). A wireless connectivity system is used to provide high-throughput and reliable wireless connectivity between moving trains and static base-stations installed along the tracks in all scenarios. The system should be designed to meet the following set of unique requirements for the transportation segment:High throughput and stable performance (low latency and jitter) to support variety of services as high definition (HD video), VoIP Telephony and high capacity Internet access In this paper RADWIN explains some topics on how to achieve the above.

14:20 ***Wireless Channel Measurements and Modeling for TCMS Communications in Metro Environments***

Iñaki Val, Aitor Arriola and Pedro Rodriguez (IK4-IKERLAN, Spain); Ana Gonzalez-Plaza and David Alonso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Lei Zhang (Universidad Politecnica de Madrid, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Juan Moreno (Metro de Madrid S.A. & Universidad Politécnica de Madrid, Spain); Carlos Rodríguez Sánchez (Metro de Madrid S.A., Spain); Eneko Echeverria and Javier Goikoetxea (Construcciones y Auxiliar de Ferrocarriles, S. A. (CAF), Spain)

In this paper, channel measurements for the 2.6 GHz band in railway environments are presented. The measurements have been carried out in the subway of Madrid in different environments (tunnel, station and open air scenarios). An intra-consist link for a future wireless Train Control and Management System (TCMS) has been measured for two types of trains, a continuous train and a non-continuous train. The results in these two trains allow checking the impact of the separation between cars in this type of links and the influence of the environment. Wideband and narrowband measurements have been carried out, and Power Delay Profile (PDP), delay spread and pathloss have been extracted and are shown in this paper. Results are useful for the design of communications systems inside train cars.

14:40 ***Scenario Modules and Ray-Tracing Simulations of Millimeter Wave and Terahertz Channels for Smart Rail Mobility***

Ke Guan, Xue Lin and Danping He (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); ZhuYan Zhao, Deshan Miao and Hao Guan (Nokia Siemens Networks, P.R. China); Thomas Kürner (Technische Universität Braunschweig, Germany)

Nowadays, rail traffic is expected to evolve into a new era of ``smart rail mobility", which requires a seamless high-data rate wireless connectivity with up to dozens of GHz bandwidth. Such a huge bandwidth requirement motivates the exploration of the underutilized millimeter (mm) wave and Terahertz (THz) bands. In this paper, six scenario modules for mm wave and THz train-to-infrastructure channels are defined and constructed for the first

time. All the main objects, such as tracks, stations, crossing bridges, tunnels, cuttings, barriers, pylons, buildings, vegetation, traffic signs, billboards, trains, etc., are modeled according to the typical geometries and materials in reality. Ray-tracing simulations show that these objects indeed influence mm wave channel properties, and therefore, they can even play a more important role in the channels at higher frequency bands -- THz. The modules presented in this paper are constructed through abstracting commonness of typical rail traffic scenarios.

15:00 ***Wireless Broadband Train to Ground Network Performance in Metro Deployments***

Julian Andrade, Carlos Moreno and Joan Vila (Huawei Technologies, Spain)

This paper presents the performance testing of a train to ground communications network deployed in an underground environment and based on IEEE 802.11ac wireless technology. A fully operational pilot project was deployed in Metro de Madrid facilities for studying the feasibility and performance of the solution. Wireless nodes have been installed in the tunnel and onboard the train. During the testing the train was moving between two stations while measuring the signal level received by the train wireless node and the TCP data throughput achieved between train and ground nodes.

15:20 ***WLAN Propagation Measurements in Railway Tunnels. Case Study: Madrid Metro***

Ignacio Bravo-Llano (Belden, Spain); Carmen Arteaga-González and Daniel Sánchez de Marcos (Alstom Transport Information Solutions, Spain)

In this work, we do an empirical approach to identify 802.11n technology Train to Ground communication specifics in underground applications from an industrial point of view. The equipment for the measurements was located aboard and along a track. The experiments consisted on measuring signal to noise ratio levels and beacon loss along a standard train cycle for physical layer performance assessment. Due to fading effects found, a break-even point should be found for Signal to Noise Ratio (SNR) Averaging level, crucial for fast handover in Dynamic Frequency Selection (DFS) environments.

15:40 ***Propagation Measurements with Regional Train at 60 GHz for Virtual Coupling Application***

Kun Yang (IFSTTAR, France); Marion Berbineau (IFSTTAR, COSYS & University Lille Nord de France, France); Jean-Pierre Ghys (IFSTTAR, COSYS, LEOST, University Lille Nord de France, France); Yann Cocheril (IFSTTAR, France); Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France)

A millimeter-wave (mmW) radio channel measurement campaign at 64.5 GHz for train's virtual coupling application was performed in a regional train in France. In this paper, we give a brief description of the channel sounder design and channel measurement campaigns with four dedicated scenarios including different setups and other channel parameters. The results of angular power distribution obtained by sweeping a horn antenna at the receiver side shows that the difference of the received signal levels (RSL) obtained at different azimuth angle of the same location can vary from 5 dB to 12 dB depending on different scenarios.

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C_P01 Millimeter Wave Radio Channels I

Cellular Communications / Regular Session / Propagation

Oral Sessions: Room 342A

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

14:00 ***Validation of Emulated Omnidirectional Antenna Output Using Directive Antenna Data***

Johannes Hejselbæk, Anders Karstensen, Jesper Ø Nielsen, Wei Fan and Gert Pedersen (Aalborg University, Denmark)

In this paper, we present validation of a method for constructing a virtual omnidirectional antenna in the azimuth plane. The virtual omnidirectional antenna utilizes a combination of data from directive horn antennas. The aim is to utilize the high gain of the horn antenna to improve the dynamic range of channel sounding measurements conducted in the centimeter and millimeter wave bands. The resulting complex impulse response from the virtual omnidirectional antenna is used to find the power-delay-profile (PDP). This is then compared to measurements conducted at the same time using a real omnidirectional antenna. The validation shows that the synthesized omnidirectional is capable of predicting main components and the slope of the PDP. Further, it is shown that by choosing angular sampling steps corresponding to the half power beam width (HPBW) of the used antenna similar power levels can be achieved.

14:20 ***Mixing Deterministic and Stochastic Propagation for Assessing MmWave Small-cell Networks***

Romain Charbonnier, Mohammed Zahid Aslam and Yoann Corre (SIRADEL, France); Yves Lostanlen (SIRADEL & University of Toronto, Canada)

Ray-based and hybrid propagation models are today considered as valuable solutions to fulfill 5G wireless channel modeling requirements. They are a complement or alternative to the stochastic approaches when link-level and system-level simulations deal with millimeter-wave (mmWave), ultra-dense deployment and/or large antenna arrays. The present article proposes an extension of an urban ray-based model for the assessment of a 60-GHz outdoor small-cell network. The multi-paths are predicted from interactions with the static environment, but also with randomly-positioned vehicles and user-bodies. Both the vehicles and the user-body generate ray-path blockage, and (in case of the vehicle) new propagation paths. This sometimes affects the cell selection or beam orientation, and significantly changes the received signal strength and inter-cell interference. The user-body blockage is illustrated on two simple use cases (single-cell and two-cell scenarios). Then the impact of both

stochastic components is assessed through the performance simulation of a whole mmWave small-cell network.

14:40 ***Frequency and Bandwidth Dependence of Millimeter Wave Ultra-Wide-Band Channels***

Naveed Iqbal (Huawei Technologies, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Christian Schneider and Diego Dupleich (Ilmenau University of Technology, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Robert Müller (TU Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

If a channel is frequency dependent then Uncorrelated Scattering (US) (a narrow-band assumption) don't hold. This has a significant impact at the considered channel modeling methodology as delay and angular dispersion of waves can no longer be studied independently because the small scale fading of individual multipath components become correlated. In this paper, we investigate the frequency dependence of the 30 GHz millimeter-Wave (mmWave) Ultra-Wide band (UWB) channel. Our indoor small lecture room measured channel results show that both delay and angular spreads vary significantly for different frequencies within a measured UWB channel. This is due to different interactions with objects in the environment due to significant difference in the comparative wavelengths. Therefore, we stress that mmWave-UWB channel modeling methodology must take into account the frequency dependence of channel parameters. In order to support its significance, we have also provided an evidence from mmWave system architecture point of view.

15:00 ***Analytic and Experimental Investigation of Beamforming Algorithms for MM-Wave Channel Characterization***

Fengchun Zhang, Wei Fan and Gert Pedersen (Aalborg University, Denmark)

Beamforming algorithms are expected to be extensively utilized in mm-wave systems to improve system performance. In this paper, we discuss three different beamforming algorithms based on uniform circular arrays (UCAs), i.e. classicial beamfomer, coventional frequency invariant beamformer. Numerical simulation results and channel sounding measurement results at mm-wave are provided to demonstrate and compare the performance of the different beamformers in channel parameter estimation applications.

15:20 ***Reflector Design to Mitigate Finger Effect on 60 GHz User Devices***

Mikko Heino (Aalto University, Finland); Clemens Icheln (Aalto University & School of Electrical Engineering, Finland); Katsuyuki Haneda (Aalto University, Finland)

In this paper, we propose a novel method to mitigate the strong shadowing effect a nearby finger has on the antenna of a handheld communications device operating at 60 GHz, by introducing reflectors on the device. When the finger is located at the distance of 3 mm of the antenna, it causes strong shadowing and the far-field radiation attenuation behind the finger is 25-34 dB. In this paper, we show that a parabolic reflector ``collar" that is placed around the antenna array can significantly reduce the shadowing in the far-field. With the collar, the far-field radiation behind the finger is improved by 19-25 dB, making the array usable even when covered by a finger. The effect of reflector size and location is studied.

15:40 ***Miners Shadowing Effects on 60 GHz Transmission Rate in Underground Mine Ricean Channels***

Mohamad Ghaddar (University of Quebec (UQAT), Canada); Mourad Nedil (UQAT, Canada); Larbi Talbi (University of Quebec - Outaouais, Canada); Tayeb A. Denidni (INRS-EMT, Canada)

Practically, 60 GHz wireless communications require highly directional antennas to overcome the severe free space loss. In underground mines, the effects of the complete blockage of line-of-sight (LOS) by miners are unavoidable. This paper presents an experimental study for assessing NLOS miner shadowing effects (MSE) on data transmission. Thus, two separate measurement scenarios are performed with and without the presence of a miner in the channel i.e, LOS, and NLOS MSE. Result show that, LOS underground mines are Ricean channels with a K-factor of 9.3 dB. However, the presence of a miner restrains K-factor to 3.6 dB. Furthermore, the experimental channel bit error rate (BER) are validated theoretically. Thus, confirming that under MSE scenario, an additional SNR of more than 13 dB is required to yield a BER of 10-4 as compared to LOS case.

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B_A01 Antennas for Biomedical Applications

Biomedical / Regular Session / Antennas

Oral Sessions: Room 342B

Chairs: Marco A. Antoniades (University of Cyprus, Cyprus), Stavros Koulouridis (University of Patras, Greece)

14:00 ***Investigation of Inductive and Radiating Energy Harvesting for an Implanted Biotelemetry Antenna***

Quang-Trung Luu (UMR 8507 CNRS, CentraleSupélec, UPMC, Université Paris-Sud, France); Stavros Koulouridis (University of Patras, Greece); Antoine M Diet (Paris Saclay - Université Paris Sud (GeePs UMR 8507 - IUT de Cachan), France); Yann Le Bihan (GEEPS, France); Lionel Pichon (CentraleSupélec - CNRS - Université Paris Sud & GeePs Laboratory, France)

A coil is integrated inside an implanted antenna in order to support inductive charging. The implanted antenna has been designed for wireless data telemetry at 402MHz region and radiating wireless charging at 915MHz. The antenna-coil system is embedded into a three layer canonical model of human arm. In the inductive charging case an external transmitting coil is considered while in the radiating charging scenario a dipole is implemented. Several simulations are carried out for the antenna-coil system. While radiating charging seems to be more efficient inductive charging can be used as a complimentary solution since they both can coexist

14:20 ***Conformal Wearable Monopole Antenna Backed by a Compact EBG Structure for Body Area Networks***

Marco A. Antoniades (University of Cyprus, Cyprus); Muhammad Ali Babar Abbasi (Frederick University, Cyprus); Marija Nikolic (University of Belgrade, Serbia); Photos Vryonides (Frederick University Cyprus, Cyprus); Symeon Nikolaou (Frederick Research Center, Cyprus)

A compact planar monopole antenna backed by an electromagnetic bandgap (EBG) structure is presented. The antenna is conformal to the human body and is intended for wearable applications in wireless body area networks. It operates at 2.45 GHz, and is fabricated on a 68mm by 38mm by 1.57mm semi-flexible substrate. The performance of the antenna does not degrade with structural bends along both of its axes, thus making it robust to structural deformation. In all cases it maintains a fractional impedance bandwidth in the range of 5%, with a gain ranging from 6.3 to 6.7 dBi. The antenna performance is also insensitive to the antenna location on the human body. For placements of the antenna on the arm, chest and leg, it maintained a 5% impedance bandwidth with radiation efficiencies above 70% and an average gain of 7.3 dBi.

14:40 ***UWB On-body Slotted Patch Antennas for In-Body Communications***

Enrique Miralles and Carlos Andreu (Institute of Telecommunications and Multimedia Applications, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain); Jose F Monserrat (Universitat Politècnica de València, Spain)

One of the most relevant challenges of next generation in-body devices consists in enhancing the medical applications of wireless networks qualitatively. The current standard does not allow high data rate wireless connections between implanted nodes. UWB systems have been considered as a potential candidate for future in-body devices. To establish a proper link within UWB, antenna matching should be ensured within the frequency range of interest. Besides, a good wave penetration trough the biological tissues is totally essential. In this work, several UWB on-body slotted patch antenna models are assessed and discussed. According to the propagation medium, the on-body antenna designs have been miniaturized and optimized taking into account the dielectric properties of human tissues. After a thorough comparison between antenna models, an optimized model has been manufactured. Finally, the performance of the optimized antenna prototype has been assessed.

15:00 ***Flexible Antenna Array for Wearable Head Imaging System***

Mohd Saiful Riza Bashri (The University of Edinburgh, United Kingdom); Tughrul Arslan (University of Edinburgh & Sensewhere Ltd., United Kingdom); Wei Zhou (Sofant Technologies, United Kingdom)

In this paper, a flexible directional monopole antenna for wearable head imaging system for stroke detection is presented. To ensure better flexibility for wearable applications, a very thin flexible PET substrate, Melinex 339 with thickness of 75μm is utilized. The size of the antenna is 70mm × 30mm. An array of 8 antennae are arranged in elliptical configuration to follow a human head contour. The antennae operate at frequency of 1.3GHz to 3.5GHz which would provide sufficient penetration and resolution. These antennae were designed and optimized to work in close proximity with human head. An investigation on mutual coupling between neighboring antennae when in close proximity with artificial human head and on free space is carried out via CST Microwave Studio and experimentation. Specific Absorption Rate (SAR) with different transmitted power level are simulated to ensure that the electromagnetic wave absorbed by human head is below the safety limit.

15:20 ***Performance of Embroidered Higher-Order Mode Antennas with Different Stitching Patterns***

Roy B. V. B. Simorangkir (Macquarie University, Australia); Yang Yang (University of Technology Sydney, Australia); Karu Esselle (Macquarie University, Australia)

In this paper the performance of TM21 resonance-mode circular patch antennas embroidered with different stitching patterns is discussed and compared. The goal is to investigate the difference in the performance when the antenna is embroidered with stitches following the antenna current paths as opposed to some simple patterns such as horizontal and vertical ones. This creates an alternative solution for embroidering prototypes of wearable antennas with complicated current distributions. The results reveal that by embroidering the antenna in line with the complex TM21 current distribution a good monopole-like radiation pattern is achieved, which is close to an etched copper prototype's used as the reference. However, with a dense horizontal stitching pattern an acceptable monopole-like radiation pattern can also be achieved with quite good gain and efficiency. While simplifying the embroidery process, the use of the simple horizontal pattern with high density suffers from high cross-polarization and thread consumption as compromises.

15:40 ***A Digitally Assisted Repeater Antenna for Implant Communications***

Sema Dumanli (Toshiba Research Europe Ltd., United Kingdom)

The wireless link between an implant and an off-body gateway may be difficult to secure due to the fact that electromagnetic waves quickly attenuate through human tissues. The signal strength may be quite weak by the time the waves reach the skin. In order to address this problem, a digitally assisted repeater antenna has been designed to be located outside of the patient's body, and act as a relay between the implant and the off-body gateway. The radiation pattern is switched between two modes depending on the link formed: in-body or off-body link. With an overall size of 30x30x3.15mm, the antenna operates in the 2.4GHz ISM band. The repeater is aimed to be used to secure wireless communications with a hip implant. Therefore, for a typical depth of such an implant of 4cm, the repeater has been shown to enable a decrease of 40dB in the transmit power level.

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H_A02 Mm-Wave Antennas for High Data Rate I

High Data-rate Transfer / Regular Session / Antennas

Oral Sessions: Room 343

Chairs: George Shaker (University of Waterloo & Spark Tech Labs, Canada), Ezzeldin Soliman (The American University in Cairo, Egypt)

14:00 ***Parallel Fed 2x1 Antenna Array Utilizing Surface Wave Cancellation on LTCC Substrate***

Josef Hagn (Intel Deutschland GmbH, Germany); Valerio Frascolla (Intel Deutschland Gmbh, Germany); Ronan Sauleau (University of Rennes 1, France); Jouko Aurinsalo (VTT Technical Research Centre of Finland, Finland); Markku Lahti (VTT Electronics, Finland); Kari Kautio (VTT Technical Research Centre of Finland Ltd, Finland)

In this paper a novel design of an UE (User Equipment) antenna for the 60-GHz band is presented. The antenna was realized on LTCC A6M-E substrate to ease a later integration with the RF-chipset on a single module. To satisfy the requirement of a relative bandwidth of 15% an electrically thick substrate was utilized, which unfortunately leads to an undesired excitation of surface waves. A suppression of these dielectric modes was achieved by employing a cancellation technique of excited surface waves. The proposed antenna consists of two parallel fed aperture coupled microstrip patch antennas. The S-parameter and radiation pattern results (simulation and measurement) are presented and are used to verify the antenna design. The manufactured antenna exhibits a -10dB impedance bandwidth of more than 9GHz, a Half Power Beam Width (HPBW) greater than 60° and a realized gain of more than 5.5dBi over the bandwidth.

14:20 ***Stacked Patch Antenna Sub-array with Low Mutual Coupling for 79 GHz MIMO Radar Applications***

Mohammad Mosalanejad (KU Leuven & IMEC, Belgium); Steven Brebels (IMEC, Belgium); Ilja Ocket (IMEC & ESAT-TELEMIC, KU Leuven, Belgium); Charlotte Soens (Imec, Belgium); Guy A. E. Vandenbosch (Katholieke Universiteit Leuven, Belgium)

In this paper, new wideband cavity backed aperture coupled microstrip antenna is presented for 79 GHz MIMO radar applications. This designs is based on a sub-arrays consisting of two single elements, which have stacked rectangular patch radiators. A microstrip to stripline transition and a series feeding topology is used to feed the elements. The antennas are manufactured by using a new high resolution multi-layer PCB technology. The performance of this antennas have been verified by both simulations and measurements. Antenna bandwidth is 9.7%, and the gain is more than 5.2dBi. Large beam widths of 138 degrees in E-plane and 40 degrees in H-plane are obtained. Antenna radiation efficiency is more than 75%, the mutual coupling between the array elements is less than -18dB.

14:40 ***High-Efficiency & Wideband Aperture Coupled Patch Antenna Fed by a Dielectric Waveguide***

Nour Nachabe (University of Nice Sophia Antipolis, France); Cyril Luxey (University Nice Sophia-Antipolis, France); Diane Titz (University Nice Sophia Antipolis, France); Frédéric Gianesello (STMicroelectronics, France); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal)

A key limitation of high gain planar microstrip antenna arrays relies in the high loss of the feeding network. In this paper, we propose an innovative way to solve this issue by feeding a microstrip patch antenna by an aperture coupled dielectric filled waveguide. Using a low loss dielectric, we managed to achieve a low loss and compact waveguide. The proposed antenna supports both V band (57-66 GHz) and E band (71-86 GHz) applications with a matching better than -10 dB and a broadside gain higher than 8 dBi. Simulated gain is notably higher than classical microstrip antenna gain [1], which is related to the high efficiency (> 90%) of the proposed antenna architecture. This innovative antenna could be used as a unit-cell for the design of a compact and high efficiency large antenna array, targeting backhaul communications at V and E bands.

15:00 ***W-band Series-Connected Patches Antenna for Multibeam Application Based on SIW Butler Matrix***

Fengchao Ren (School of Information Science and Engineering, Southeast University, P.R. China); Wei Hong (Southeast University, P.R. China); Ke Wu (Ecole Polytechnique (University of Montreal) & Center for Radiofrequency Electronics Research of Quebec, Canada)

This letter presents a series-connected patch array antenna aperture-coupled by substrate integrated waveguide (SIW), which produces narrowed E-plane beamwidth for improving antenna gain. With this special patch array, W-band multibeam array capable of offering switchable beams in H-plane is designed by means of SIW Butler matrix. The simulation and experiment results show good impedance matching and port-to-port isolation, as well as specific beams associating with four input ports, well demonstrating the validity of this design. Additionally, the antenna is developed by printed circuit board (PCB) technology, characterizing of planar profile, high-level integration, low cost and small weight

15:20 ***Novel Micromachined On-Chip 10-Elements Wire-Grid Array Operating at 60 GHz***

Mai Sallam (The American University in Cairo & Katholieke Universteit Leuven, Egypt); Mohamed Serry (The American University in Cairo, Egypt); Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia); Sherif Sedky (AUC, Egypt); Ezzeldin Soliman (The American University in Cairo, Egypt)

This paper presents a new topology for a wire-grid antenna array which operates at 60 GHz. The array consists of ten λg/2 dipole radiators connected via non-radiating connectors. Both radiators and connectors are placed on top of narrow silicon walls. The antenna is fed with a coplanar microstrip lines placed at the other side of the wafer and is connected with its feeding transmission lines using through-silicon-vias. The antenna is optimized for two cases: using high- and low-resistivity silicon substrates. The former has better radiation characteristics while the later is more compatible with the driving electronic circuits. The antenna has high directivity, reasonable bandwidth and high polarization purity.

15:40 ***Wideband Cavity-Backed Slot Subarray with Gap Waveguide Feed-network for D-band Applications***

Abbas Vosoogh, Ashraf Uz Zaman and Vessen Vassilev (Chalmers University of Technology, Sweden)

simple and wideband subarray for D-band applications is presented in this paper. The proposed multilayer subarray consists of 2x2 cavity-backed slot subarray fed by a ridge gap waveguide transmission line. The simulated results show that the proposed subarray has a relative impedance bandwidth of 22.5% with input reflection coefficient better than -10 dB over the 126-158 GHz frequency band. An array antenna consisting of 8x8 slots is designed with the proposed subarray. The simulation results of the proposed subarray and antenna are presented.

Monday, March 20, 14:00 - 18:30

CS20 In Memory of Prof. Per Simon Kildal (Dedicated session)

TOP

Future Applications / Convened Session / Antennas

Oral Sessions: Room 351

Chairs: Madeleine Schilliger Kildal (Chalmers University of Technology & Bluetest AB, Sweden), Stefano Maci (University of Siena, Italy), Eva Rajo-Iglesias (University Carlos III of Madrid, Spain), Zvonimir Sipus (University of Zagreb, Croatia)

14:00 ***Remembering Per-Simon Kildal: Soft in Heart and Hard in Technical Work***

Yahya Rahmat-Samii (University of California Los Angeles (UCLA) & UCLA, USA)

Professor Per-Simon Kildal passed away on April 21, 2016, after a very short period of illness. He was born on July 4, 1951. He chaired the Division of Antenna Systems of the Department of Signals and Systems at Chalmers University of Technology. He authored an antenna textbook and many journal articles and conference papers. He designed two very large antennas, including the Gregorian dual-reflector feed of the Arecibo radio telescope. He was the originator of the concept of soft and hard surfaces, recently resulting in the gap waveguide, a new low-loss meta-material-based transmission line. His research group pioneered the reverberation chamber into an accurate measurement tool for antennas and wireless terminals. Prof. Kildal was the recipient of two Best Paper Awards for articles published in the IEEE Antennas and Propagation Transactions, and he was the recipient of the 2011 Distinguished Achievements Award of the IEEE Antennas and Propagation Society.

14:20 ***Per-Simon Kildal: Friend, Scientist, Educator, Entrepreneur***

Stefano Maci (University of Siena, Italy)

Professor Per-Simon Kildal passed away on April 21, 2016, at age 65. Since 1989, he was a Professor with Chalmers University of Technology, Gothenburg, Sweden, where he led the Division of Antenna Systems of the Department of Signals and Systems. The life of Professor Kildal was dedicated to Science, Education and Engineering. This paper summarizes these three aspects of his life, starting form his main scientific achievements concerned with the Arecibo radio telescope, the invention of ultra-broadband "Eleven antenna", the metasurface precursor concept of "soft and hard surfaces", and the recent "gap waveguide". His contributions on high level education inside the European School of Antennas is reviewed, as well as his entrepreneurship activity, centered around the ideas of reverberation chamber for measurements of wireless terminals, and on electronic packaging by EBG materials.

14:40 ***Trondheim - The Launching Pad for Per-Simon Kildal's Extraordinary Career***

Erik Lier (Lockheed Martin Corporation, USA)

Per-Simon's rise to fame started at the Norwegian University of Science and Technology in Trondheim in the late 1970s. In this paper I will reflect on those years and how it may have shaped his career.

15:00 ***Applications of Soft and Hard Surfaces in the Era of Metamaterials***

Eva Rajo-Iglesias (University Carlos III of Madrid, Spain); Malcolm Ng Mou Kehn (National Chiao Tung University, Taiwan)

During the beginning of the 2000s, amidst the boom of metamaterials, EBG structures and AMC surfaces, the authors of the paper had the privilege of working with Professor Kildal on revisiting the concept of soft and hard surfaces, which was already established for a decade at that time. These belong to the category of artificial surfaces with the ability of providing unexpected boundary conditions in a given frequency range. In parallel with metamaterials, we present a summary of some of the applications that were developed, among them hard waveguides or invisible struts. Meeting Per-Simon has changed our lives for better forever.We are now established researchers and we met him at the beginning of our carriers. We have been very close friends and collaborators with him all along these years. We feel now like orphans and our lives will never be the same without his supportive friendship and inspiration.

15:20 ***A Clear Path in the Design of Electromagnetic Structures***

Zvonimir Sipus (University of Zagreb, Croatia)

This paper overviews the research activities of Prof. Per-Simon Kildal's group regarding structuring the design of different electromagnetic components and software subroutines. Through his work Prof. Kildal always had a clear path in the design process of electromagnetic devices and concepts, and this approach will be demonstrated through a couple of examples. The first will focus on the design of different types of periodic structures through efficient use of canonical boundary conditions. In the second, a general algorithm based on equivalence principle for calculating Green's functions of canonical multi-layered structures will be shown.

15:40 ***The General EM Solver G2DMULT and Application to Analysis of New Developed Random-LOS Measurement Facility***

Jian Yang (Chalmers University of Technology, Sweden)

G2DMULT is a general solver for antennas and electromagnetic problems that have almost two-dimensional geometries. The frame of the code G2DMULT was developed by Prof. Per-Simon Kildal. This paper reviews the principles and the developments of the code, and its new application to Ramdom-LOS measurement system which was proposed by Kildal, too.

16:00 Coffee Break

16:30 ***Research Collaboration on Waveguide Slot Array Antennas Between Prof. Kildal and Tokyo Tech***

Jiro Hirokawa and Makoto Ando (Tokyo Institute of Technology, Japan)

This paper overviews the research collaboration on waveguide slot array antennas between Prof. Per-Simon Kildal and Tokyo Institute of Technology. Also, the development of the plate-laminated waveguide by Tokyo Tech is presented.

16:50 ***Reverberation Chamber for OTA Measurements: The History of a Dream!***

Jan Carlsson (Provinn AB, Sweden); Christian Lötbäck (Bluetest AB, Sweden); Andrés Alayon Glazunov (Chalmers University of Technology, Sweden)

In the late 1990´s Professor Per-Simon Kildal got the idea that reverberation chambers could be used for characterizing small antennas and mobile devices. Many thought the idea was crazy but he was persistent and worked hard to realize his dream to build a small chamber that could be used by the wireless industry. This paper gives a short history of the research at Chalmers and the creation of the company Bluetest that both were instrumental for realizing the dream.

17:10 ***How Gap Waveguides Were Conceived***

Alejandro Valero-Nogueira (Universidad Politécnica de Valencia, Spain); Esperanza Alfonso (Gapwaves AB, Gothenburg, Sweden)

In this paper the steps that led to gap waveguide conception are surveyed. Background, main physical property exploited and its implications are discussed. Nevertheless, applications resulting from the original idea are also reviewed.

17:30 ***Three Decades Journey from Real to Artificial with Kildal***

Ahmed Kishk (Concordia University, Canada)

In memory of Professor Per-Simon Kildal, kishk presents an overview of the collaboration between them. It can be considered as a brief review of the subjects that were of mutual interest between them. Most of their work pointed toward simplification of complicated structures through the understanding of the physical meaning of boundary conditions. Kildal's contributions were directed towards commercial applications through his clear vision for the future. The paper tells a successful story of long-term collaborations between their research groups. Other research groups should be encouraged to follow such an example.

17:50 ***One Meter Deployable Reflectarray Antenna for Earth Science Radars***

Nacer Chahat (NASA-JPL, Caltech, USA); Jonathan Sauder (NASA-JPL / Caltech, USA); Gregory Agnes and 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. It operates at 35.75 GHz for the measurement of atmospheric processes over a short, evolutionary timescale. It deploys into a 98.6 cm × 82.1cm flat reflector. This antenna provides a gain of 48.0 dBi and an aperture efficiency of 44%. It consists of a cassegrain reflectarray using 14 deployable panels, one fixed panel and a telescoping feed and subreflector. This paper is written in celebration of Per-Simon Kildal: a scholar, mentor and friend. Per-Simon's broad interests and delightful passion led him to the Jet Propulsion Laboratory and Caltech in Pasadena, CA many times over his career. Professionally, Per-Simon's work in multi-reflector antenna design and analysis developed for his work at the Arecibo Observatory influenced developments in the NASA/JPL Deep Space Network beam-waveguide antenna design. At the same time, his work on multi-reflector antenna synthesis and its associated asymptotic diffraction effects were seminal pieces of research that simplified the engineering design and construction of very large antennas. His brilliant and intuitive grasp of seamlessly connecting the theoretical to the practical is remarkable. Personally, Per-Simon's infectious curiosity and humorous nature led to productive interactions across nationalities and disciplines leading to collegial partnerships, teaching, mentoring and life-long friendships. This paper applies traditional concepts of reflectarray antennas to low-cost and innovative cubesat platforms for space-based remote sensing. It is dedicated to and inspired by Per-Simon's wonderful drive to innovate and find great solutions.

18:10 ***Closing of the Session in Memory of Prof. Per-Simon Kildal***

Madeleine Schilliger Kildal (Chalmers University of Technology & Bluetest AB, Sweden)

This paper is dedicated to close the session in memory of Per-Simon Kildal. It will be presented by his daughter: Madeleine Schilliger Kildal.

Monday, March 20, 14:00 - 16:00

R_M01 RCS Measurements

TOP

Radars / Regular Session / Measurements
Oral Sessions: Room 352A
Chairs: Jean-Michel Geffrin (Institut Fresnel & Aix Marseille Univ, CNRS, Centrale Marseille, France), Alexander Yarovoy (TU Delft, The Netherlands)

14:00 ***On the Interest of a Bistatic Radar Cross Section Setup to Measure Various Scattering Quantities***

Jean-Michel Geffrin (Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, Marseille, France); Hassan Saleh (Centre Commun de Ressources en Microondes, Institut Fresnel, France); Christelle Eyraud (Institut Fresnel, Aix Marseille Université, CNRS, Centrale Marseille, France); Amélie Litman (Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France)

This paper describes how the bistatic radar cross section (RCS) experimental setup of the "Centre Commun de Ressources en Microondes" (CCRM) was used to precisely determine various scattering quantities and how we took profit of the large scattering angular range available with this setup. Results on extinction cross section, linear degree of polarization and other scattering quantities of interest are presented. We also show how those results are interesting in different domains where scattering phenomena are studied thanks to the scale invariance properties of the Maxwell equations using the so called microwave analogy.

14:20 ***Bistatic Scattering Measurement on Low Permittivity Spheroidal Objects***

Hassan Saleh (Centre Commun de Ressources en Microondes, Institut Fresnel, France); Jean-Michel Geffrin (Institut Fresnel & Aix Marseille Univ, CNRS, Centrale Marseille, France); Hervé Tortel (Institut Fresnel, Aix Marseille Université, CNRS, Centrale Marseille, France)

In this paper we present our advances in the scattering measurement of low electromagnetic signature objects. The targets under test are spheroids of low permittivities and of sizes compared to the wavelength. The measurements were carried-out at the experimental facility of the "Centre Commun de Ressources en Microondes" (CCRM) in bistatic configuration and using a hard-gating noise reduction system. The measurements were further assessed through comparisons to computations with Finite Element Method. Good agreement is reported.

14:40 ***Range Segmentation for micro-Doppler of Backscattered Field by Wind Turbines***

Stefano Medagli (TU Delft); Oleg Krasnov (Delft University of Technology, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

In this paper, a simple electromagnetic model for wind turbine's backscattering is proposed. The wind turbine is modeled as a linear structure made of three rotating wires on which an electromagnetic fields impinges. Since a wind turbine is much bigger than typical radar range resolution cells, just a small part of it is involved in the backscattering for a single resolution cell. An analysis of the micro-Doppler features for each range cell involving the wind turbine is then proposed. The models are both compared and validated using real data acquired with PARSAX radar. The main features obtained from these models can be used to understand the backscattering mechanisms for a wind turbine and for developing of clutter mitigation algorithms.

15:00 ***RF Front End for UAS-Aided Flight Inspection of Airport Surveillance Radars***

Jürgen Fitschen and Sebastian Koj (Leibniz Universität Hannover, Germany); Jochen Bredemeyer (FCS Flight Calibration Services GmbH, Germany); Heyno Garbe (Leibniz Universität Hannover, Germany)

Flight inspection of radio-based terrestrial navigation systems is crucial for sufficient accuracy. Especially in proximity of wind turbines (WT), flight inspections must be carried out. This causes problems that hinder the usage of conventional aircraft. To solve this problem, unmanned aerial systems (UAS), such as multicopters, are a promising approach. Beside the solution of the clearance problem, they also provide further benefits in terms of cost effectiveness and flexibility. Since commercial off-the-shelf (COTS) test receivers exceed the UAS's loading capabilities, we developed a weight- and size-optimized test receiver that can compete with full-compliance measurement COTS devices. This has been achieved by focusing on the demands regarding carrier frequency and bandwidth of the system under test (SUT). In this paper we describe the RF front end for the reception of the forward scatter emitted by the airport surveillance radar (ASR) and show the first measurement results.

15:20 ***Interlaboratory Comparisons of Radar Cross Section Measurements by the "GTi", Criteria Suggestions***

Juan-Carlos Castelli (ONERA, France); Fabrice Comblet (ENSTA Bretagne, France); Franck Daout (GEA universite Paris 10, France); Christelle Eyraud (Institut Fresnel, Aix Marseille Université, CNRS, Centrale Marseille, France); Sylvie Fargeot (AIRBUS Defence and Space, France); Régis Guillerey (DGA, France); Jean-Michel Geffrin (Institut Fresnel & Aix Marseille Univ, CNRS, Centrale Marseille, France); Samuel Leman (NEXIO, France); Pierre Massaloux (CESTA, France); Genevieve Maze-Merceur (CEA, France); Gerard-Pascal Piau (EADS CCR, France)

A comparison of Radar Cross Section (RCS) measurement results between several French measurement indoor facilities has been organized in the framework of a French Working Group (Groupe de Travail sur les incertitudes en chambre anéchoïque: GTi), dealing with measurement uncertainties in anechoic chamber. The GTi involves 22 laboratories that are either industrial or academic research ones, or laboratories depending on public organisms. Three tasks have been defined: 1/ State of the art, 2/ Comparisons of RCS measurements, 3/ Comparisons of Antenna Measurements. This paper deals with the second task, in which 8 laboratories are engaged. The motivations and the tasks are described in this paper and results will be presented at the conference. Comparison criteria will also be proposed.

15:40 ***A Study of Aircraft Detection Using DTTB Signal Delay Profile***

Takuya Otsuyama and Junichi Honda (Electronic Navigation Research Institute, Japan)

The current Air Traffic Management (ATM) uses a combination of several radar system. However, the conventional

Primary Surveillance Radar (PSR) have a high cost of the operation in comparison with usage. Recently, Multi-Static Primary Surveillance Radar (MSPSR) has attracted interest from the civil aviation research field. The MSPSR system use not only the conventional radar signals but also other radio waves, such as Digital Terrestrial Television Broadcasting (DTTB). In this paper we described the experimental results of aircraft detecting by using DTTB signals and the potential of the aircraft detection by proposed method.

CS24 Measurements and Simulations in Channel Modelling in Wireless Body Area Networks (COST CA15104 IRACON)

TOP

Localization & Connected Objects / Convened Session / Propagation
Oral Sessions: Room 352B
Chairs: Slawomir J. Ambroziak (Gdansk University of Technology, Poland), Luis M. Correia (IST - University of Lisbon & INESC, Portugal)

14:00 ***UWB In-Body Channel Performance by Using a Direct Antenna Designing Procedure***
Carlos Andreu (Institute of Telecommunications and Multimedia Applications, Spain); Concepcion Garcia-Pardo (Universitat Politècnica de València & Institute of Telecommunications and Multimedia Applications (iTEAM), Spain); Alejandro Fornes-Leal (Institute of Telecommunications and Multimedia Applications, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Narcis Cardona (The Polytechnic University of Valencia, Spain)
UWB systems have been proposed as a candidate for the next generation of in-body applications. In order to perform reliable UWB channel measurements, implantable antennas should work in the propagation medium properly. To assess the UWB channel performance, in-body antenna matching should be assured. Besides, an omnidirectional radiation pattern in order to communicate with a sensor array located around the body should be achieved. This paper is devoted to the analysis of the UWB in- body channel when using an antenna miniaturization procedure that maintains its omnidirectional radiation pattern as well as its operation bandwidth. For that, an UWB monopole antenna with circular patch is directly miniaturized and optimized considering the human muscle tissue. To assess the impact of antenna miniaturization, the results of the channel propagation measurement campaign obtained with the miniaturized antenna are compared with those obtained from a larger UWB monopole in a previous measurement campaign.

14:20 ***Consideration of Antenna Directions for High Frequency Wireless Body Area Networks During Human Walking Movement***
Takahiro Aoyagi (Tokyo Institute of Technology, Japan)
As increased requirements for much high speed and capacity telecommunications, frequency bands of wireless communications become higher such as millimeter wave or terahertz wave. In these high frequency bands, beam foaming is employed to gain stable connectivity. On-body body area network is one of fascinate application of these high capacity frequency bands. However, directions of on-body antennas largely fluctuates and shadowing frequently occurs due to human movements. In this paper, variation of antenna directions and shadowing of on-body propagation during human walk movement is investigated. As a result, range of antenna rotation and shadowing rate, which can be used future system design of high frequency body area networks, is clarified.

14:40 ***Composite Fading in Non-line-of-Sight Off-Body Communications Channels***
Seong Ki Yoo (Queen's University Belfast, United Kingdom); Simon Cotton (Queen's University, Belfast, United Kingdom)
In this paper, we investigate the characteristics of the composite fading observed in non-line-of-sight (NLOS) off-body communications channels using the η-μ/inverse gamma distribution. We use a number of different datasets obtained from NLOS off-body measurements which have been performed in a range of different environments at 5.8 GHz and 60 GHz. In all cases, the bodyworn node was positioned on the front-central chest region of an adult male. It is shown that the η-μ/inverse gamma model provides an excellent fit to the measurement data for all of the considered cases. Using the Akaike information criterion (AIC), we have compared the -/inverse gamma model with other composite and non-composite fading models associated with the NLOS channel conditions. The AIC results confirm that the η-μ/inverse gamma model was the most likely model to have been responsible for generating the channel data from the set of candidates which were considered.

15:00 ***An Empirical Model for the Polarisation Characteristics of Indoor Off-Body Channels***
Kenan Turbic (INESC-ID / Instituto Superior Tecnico (IST), University of Lisbon, Portugal); Slawomir J. Ambroziak (Gdansk University of Technology, Poland); Luis M. Correia (IST - University of Lisbon & INESC, Portugal)
This paper presents an analysis of the polarisation characteristics for the channel in dynamic off-body communications, and an empirical channel model, based on measurements performed at 2.45 GHz in an office environment. Body presence and propagation conditions have a strong influence on signal depolarisation. The model assumes three components for the total path loss: mean path loss, represented by a log-distance function with a path loss exponent of 1.71, Lognormal-distributed shadowing fading, and Nakagami-distributed multipath fading. The Nakagami Distribution shows a trend towards the Rice one in the co-polarised and the Rayleigh one in the cross-polarised channels.

15:20 ***Key Generation Based on Fast Reciprocal Channel Estimation for Body-Worn Sensor Nodes***
Patrick Van Torre, Quinten Van den Brande and Jo Verhaevert (Ghent University, Belgium); Jan Vanfleteren (Ghent University and IMEC, Belgium); Hendrik Rogier (Ghent University, Belgium)

With the advent of the Internet of Things, body-worn sensor nodes are continuously becoming more important. In case of bio-medical, rescue-worker or military applications sensitive data are often transmitted, requiring the need for encryption. Body-worn sensor nodes are generally employed in quickly varying channel conditions due to body movement. The radio-communication channel between such nodes is however reciprocal, allowing the extraction of an array of similar channel measurements at both ends of the link. These data can be used to build equal encryption keys at both link ends. This paper studies the practical performance of an enhanced channel-based key generation system with a very short round-trip delay. Measurements were performed using the new system and the results of the enhanced key generation are evaluated. Although the performance is slightly increased thanks to the shorter round-trip delay, the accuracy of the signal level detector still imposes limits.

15:40 ***Internet of Animals: On-and Off-body Propagation Analysis for Energy Efficient WBAN Design for Dairy Cows***

Said Benaissa (Ghent University/iMinds, Belgium); David Plets (Ghent University - iMinds, Belgium); Emmeric Tanghe, Gunter Vermeeren and Luc Martens (Ghent University, Belgium); Bart Sonck, Frank Tuyttens and Leen Vandaele (Institute for Agricultural and Fisheries Research (ILVO), Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper presents propagation modelling of different on-body and off-body wireless communication scenarios for dairy cows in barns at 2.4 GHz. Based on the obtained propagation models, a WBAN that monitors multiple heath parameters is designed for optimal performances in terms of energy efficiency and packet error rate.

TOP

MT_A01 Integral Equations

Methods & Tools / Regular Session / Antennas

Oral Sessions: Room 353

Chairs: Elizabeth Bleszynski (Monopole Resesarch, USA), Francesca Vipiana (Politecnico di Torino, Italy)

14:00 ***Reduction of Singular Surface Integrals to Non-Singular Line Integrals in Integral Equations Involving Non-Parallel Surface Elements***

Elizabeth Bleszynski (Monopole Resesarch, USA); Marek Bleszynski, Dr (Monopole Resaearch, USA); Thomas Jaroszewicz (Monopole Research, USA)

A novel procedure is presented for the evaluation of matrix elements of the tensor Green function with Rao-Wilton-Glisson basis functions appearing in surface integral equations in electromagnetics. The procedure,contitutres the generalization of our previous result to non-planar geometries, reduces four- dimensional surface integrals with singular integrands to line integrals over triangle edges with regular integrands. The main advantage of the derived expressions is that they offer simplicity and easily controllable accuracy achieved at a computational cost significantly lower than for previously considered techniques, in particular the conventional singularity subtraction method.

14:20 ***Acceleration of 4-D Reaction Integrals in the Method of Moments via Double Application of the Divergence Theorem and Variable Transformations***

Javier Rivero (University of Extremadura, Spain); Francesca Vipiana (Politecnico di Torino, Italy); Donald Wilton (University of Houston, USA); William Johnson (New Mexico Institute of Mining and Technology)

In this paper we propose a scheme to treat, as a whole, the 4-D reaction integrals appearing in the Method of Moments. The surface divergence theorem is twice applied directly in the physical space domain, thus eliminating restrictions to well-shaped, touching elements required by mapping to an angle-distorting normalized coordinate system together with an appropriate integration reordering. The resulting 4-D surface integral is expressed as two radial integrals plus two contour integrals over source and observation domain boundaries. The radial integrals significantly smooth the kernel, and the resulting contour integrals are further regularized for efficient numerical evaluation.

14:40 ***Nonconforming Discretization of the PMCHWT Integral Equation Applied to Arbitrarily Shaped Dielectric Objects***

Ivan Sekulic and Eduard Ubeda (Universitat Politècnica de Catalunya (UPC), Spain); Juan M. Rius (Universitat Politècnica de Catalunya, Spain)

The Poggio-Miller-Chan-Harrington-Wu-Tsai (PMCHWT) integral equation is widely used in the scattering analysis of dielectric bodies. The RWG set is normally adopted to expand the electric and magnetic currents in the Method of Moments (MoM) discretization of the PMCHWT formulation. This set preserves normal continuity across edges in the expansion of currents. However, in the analysis of composite objects, the imposition of such continuity constraint around junctions, where several regions intersect, becomes convoluted. We present a new nonconforming discretization of the PMCHWT formulation so that currents are expanded with no continuity constraint across edges. This becomes well-suited for the analysis of composite objects or nonconformal meshes, where some adjacent facets have no common edges. We show RCS results where the nonconforming PMCHWT implementation, facet-oriented, shows similar or better accuracy as the conventional approach, edge-oriented, for a given degree of meshing.

15:00 ***Enhanced MoM for the Analysis of Multilayered Periodic Structures Containing Dipoles with Application to the Design of Reflectarray Antennas***

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

Agency, The Netherlands)

The spectral domain Method of Moments (MoM) is customarily used in the analysis of multilayered periodic structures. In this paper a hybrid MoM is introduced for the analysis of multilayered periodic structures containing sets of dipoles at two metallization levels. In the hybrid MoM the matrix entries involving basis functions of dipoles at different metallization levels are computed in the spectral domain. However, the matrix entries involving basis functions at the same metallization level are computed in the spatial domain. The implemented hybrid MoM is applied to the design of multilayered reflectarray antennas made of dipoles under the local periodicity assumption. Thanks to the use of interpolated expressions for the periodic spatial Green's functions in terms of both coordinates and incidence angles, the CPU time required by the hybrid MoM in the design of the antennas is around twenty times faster than that required by the spectral domain MoM.

15:20 ***Locally Corrected Nyström Technique and Its Relationship with RWG Method of Moment for Current Reconstruction Using Very-Near-Field Measurements***

Rezvan Rafiee Alavi (University of Alberta); Ali Kiaee, Rashid Mirzavand and Pedram Mousavi (University of Alberta, Canada)

The Locally corrected Nyström (LCN) method is used for current reconstruction on the surface of microwave boards and antennas. A relationship is established between LCN and RWG method of moment (MoM) for this application to enforce current continuity. This approach allows designers to find, characterize, and address the cause of a design failure in a microwave board or an antenna under test. The advantage of this method over the conventional method of moment (MoM) is that as a point-based approach efficiency can be enhanced in its acceleration with the multilevel fast multipole algorithm (MLFM).

15:40 ***Reduction of Volume-Volume Integrals Arising in Galerkin JM-VIE Formulations to Surface-Surface Integrals***

Ioannis Georgakis and Athanasios Polimeridis (Skolkovo Institute of Science and Technology, Russia)

The numerical evaluation of current-based volume integral equation formulations typically involves 6-D integrals with kernels that exhibit strongly singular or weakly singular behavior when observation points coincide with source points.We demonstrate that these integrals can be reduced to 4-D integrals with smoother kernels that are amenable to numerical evaluation by means of well-established numerical schemes originally developed for surface integral equation formulations.

TOP

CS01 A Century After Tesla: How Far Have We Come With Wireless Power Transfer ?

Future Applications / Convened Session / Antennas

Oral Sessions: Room 362/363

Chairs: Yi Huang (University of Liverpool, United Kingdom), Huib J. Visser (IMEC Netherlands, The Netherlands)

14:00 ***A Brief History of Radiative Wireless Power Transfer***

Hubregt J. Visser (imec The Netherlands, The Netherlands)

The position of radiative Wireless Power Transfer (WPT) in the spectrum of power harvesting is given and a brief history of radiative WPT, starting with the work of Faraday is presented. The challenges in increasing the received dc power level or the transfer distance are outlined and possible directions for a solution are indicated.

14:20 ***Far Field WPT - Main Challenges***

Daniel Belo (Universidade de Aveiro & Instituto de Telecomunicações, Portugal); Nuno Borges Carvalho (University of Aveiro/IT Aveiro, Portugal)

In this paper the main challenges that far field wireless power transmission should deal with will be presented and discussed. New developments made in Aveiro University in order to solve some of the issues raised will also be discussed, those include the use of special design waveforms, special design of antennas for WPT and also alternatives for WPT RF-DC conversion efficiency.

14:40 ***Light-Weight Wireless Power Transfer for Mid-Air Charging of Drones***

Paul Mitcheson, Samer Aldhaher, David Christopher Yates, George Kkelis and Juan Arteaga (Imperial College London, United Kingdom)

Recent developments in inductive wireless power transfer (WPT) mean that the technology has reached a point where powering small drones has become feasible. Fundamentally, drones can only carry limited payloads and thus require light-weight WPT receiver solutions. The key to achieving light weight is operating the WPT system at high frequency: this allows both the coils and the electronics to achieve very high power densities. When operated in the MHz region, the WPT coils can be manufactured without the need for ferrite, because the low coupling factor can be offset by very high coil Q factors. To make efficient MHz power conversion circuits, wide band-gap semiconductors, including SiC and GaN have provided a step change. For powering a drone, these devices are integrated into soft-switching resonant inverter and rectifier topologies and are able to operate efficiently at tens of MHz.

15:00 ***Recent Advances in Broadband Rectennas for Wireless Power Transfer and Ambient RF Energy Harvesting***

Chaoyun Song, Yi Huang and Jiafeng Zhou (University of Liverpool, United Kingdom); Paul Carter (Aeternum, LLC, USA)

Wireless energy harvesting from ambient electromagnetic fields is becoming an emerging technology that can be exploited as a power source for many low power electronic devices. A number of key challenges are identified but

the optimum design of rectennas for ambient WEH is very challenging. This paper presents a review on recent progress in multiband and broadband rectennas for WEH and wireless power transfer and introduces the latest research on this topic at the University of Liverpool, UK. In addition to the existing technologies, we have developed a number of novel techniques to develop rectennas with a simple structure, a broad bandwidth and an improved RF-DC conversion efficiency. Moreover, our rectennas can achieve consistent performance for a dynamic input power level or a wide load impedance range. The state-of-the-art technologies presented in this paper could have a great impact on the future development of rectennas for many related applications.

15:20 ***RF-Powered, Backscatter-Based Cameras***

Saman Naderiparizi, Zerina Kapetanovic and Joshua R. Smith (University of Washington, USA)

RF-powered devices equipped with general-purpose microcontrollers face energy limitation constraints for performing arbitrarily complex sensing/computation tasks. While richer capabilities such as image capture and processing would enable many new RF-powered use-cases, this energy limitation narrows the application space. Enabling richer sensing tasks has two main challenges: efficiently retaining harvested energy, and storing/communicating large quantity of sensor data. This paper reviews the WISPCam design, an RF-powered programmable camera. WISPCam integrates an off-the-shelf VGA camera which is a rich sensor example energy and data wise. The paper also presents an ultra-low power scheme that is able to provide periodic updates on charge state of the device before enough energy has been accumulated for image capture. This paper presents a novel data storage and bi-directional communication scheme that enables reliable transfer of complete images to an RFID reader application even when packets are lost or the device runs out of energy.

15:40 ***Study on 5.8 GHz Single-Stage Charge Pump Rectifier for Internal Wireless System of Satellite***

Ce Wang and Naoki Shinohara (Kyoto University, Japan); Tomohiko Mitani (Kyoto Universiy, Japan)

For reducing the weight of a satellite, an internal wireless system of satellite is proposed in a previous study. It is a system that can communicate between the subsystems of a satellite by carrying wireless communication modules. In this paper, we propose a complete internal wireless system of satellite with microwave wireless power transmission technology, and designed a 5.8 GHz highly efficiency rectifier circuit based charge pump circuit, and introduced a class-F load. We compared the rectifying efficiency of single shunt rectifier and charge pump rectifier theoretically, the conclusion is that they should have the same conversion efficiency, and this result are verified by experiment. The conversion efficiency increase to 78 % at 30 mW in the simulation, and obtained about 71 % conversion efficiency in the experiment. In addition, the output voltage is higher than 5 V at optimum load.

Monday, March 20, 16:30 - 18:30

CS08 Advances on Transformation Electromagnetics Based Antennas

TOP

Future Applications / Convened Session / Antennas

Oral Sessions: Room 341

Chairs: Shah Nawaz Burokur (LEME, France), Anne-Claire Lepage (Institut Mines-Telecom, Telecom ParisTech, France)

16:30 ***Beam Squinting Metalens Design and Its Application to Multibeam Reflector Feeds***

Mario Mencagli, Jr., Francesco Caminita and Enrica Martini (University of Siena, Italy); Patrizio De Vita (IDS Ingegneria Dei Sistemi, Italy); Valentina Sozio (Istituto Superiore Mario Boella, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Stefano Maci (University of Siena, Italy)

This contribution presents the design of a metalens providing a desired beam squint with negligible reflections. This devices is applied at the mouth of a conical horn with the objective to obtain a squinted beam feed, that is advantageous in multibeam antenna applications. The metalens consists of three metallic layers, whose constituent elements are chose so as to provide all the required impedance values with smooth variations across the horn aperture. Full wave results are reported to validate the design.

16:50 ***Broadband Metasurface Luneburg Lens Antenna Based on Glide-Symmetric Bed of Nails***

Kexin Liu, Fatemeh Ghasemifard and Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

A broadband metasurface Luneburg lens based on glide-symmetric bed of nails is designed. First, the Luneburg lens was re-shaped using quasi-conformal transformation optics. With this technique, the original circular focal curve of the lens is changed to a straight line. Afterwards, the refractive index distribution of the optically transformed lens is realized by changing the height of the pins in a bed of nails configuration. The complete Luneburg lens is simulated in CST Microwave Studio and the results demonstrate that the lens has 8-16 GHz bandwidth.

17:10 ***Scattering Free Graded Index Profiles and the Control of Electromagnetic Fields***

Benjamin Vial (Queen Mary, University of London, United Kingdom); Yangjie Liu (Nanyang Technological University, United Kingdom); Simon Horsley and Thomas Philbin (University of Exeter, United Kingdom); Yang Hao (Queen Mary University, United Kingdom)

We present a general methodology to arbitrarily manipulate the amplitude and phase of an electromagnetic wave propagating in a two-dimensional medium, without introducing any scattering. This leads to a class of isotropic

spatially varying permittivity and permeability profiles that are transparent to an incident plane wave while shaping the field magnitude. Furthermore, we propose a metamaterial structure working in the infrared that demonstrates deep sub-wavelength control of the electric field amplitude and strong reduction of the scattering.

17:30 ***Transformation Electromagnetics and 3D Printing: Devices for Novel Antenna Solutions***

Jianjia Yi (Xidian University, P.R. China); André de Lustrac (Institut d'Electronique Fondamentale - Université Paris-Sud, France); Gerard-Pascal Piau (EADS CCR, France); Shah Nawaz Burokur (LEME, France)

Transformation Electromagnetics is applied to design electromagnetic devices for focusing and collimating applications at microwave frequencies. Three devices are studied and conceived by solving the Laplace's equation that describes the deformation of a medium in a space transformation. Prototypes are fabricated using low-cost dielectric 3D printing technology. The first device is used to compensate for the curvature of a non-planar antenna array, the second one is applied to steer an electromagnetic beam and the last one is used to taper the flow of an electromagnetic field. These devices can find potential applications in novel antenna concepts.

17:50 ***Transformation Electromagnetics Enabled Lens Design with Surrogate-Assisted Global Optimization***

John Easum, Jogender Nagar and Sawyer Campbell (The Pennsylvania State University, USA); Douglas H Werner and Pingjuan Werner (Pennsylvania State University, USA)

A gradient index lens is designed by utilizing quasi-conformal transformation electromagnetics (qTEM) to define the index distribution in a rotationally symmetric lens. The smooth and continuous nature of qTEM is investigated and an analytical surrogate model is trained to replace the computationally intensive qTEM procedure and ray trace simulations. The surrogate model is then incorporated into an optimization strategy which is able to converge to an optimal design in substantially fewer function evaluations than a traditional global optimization scheme.

18:10 ***Ultra-thin Metalens for Multibeam Emission Based on Transformation Optics***

Kuang Zhang, Guohui Yang, Xumin Ding, Meng Fan-Yi, JiaHui Fu and Wu Qun (Harbin Institute of Technology, P.R. China)

A general design of metalenses for N-beam emissions is proposed based on transformation optics. A linear transformation mapping is adopted to achieve the homogeneous characterization of the transforming medium, which is therefore easy to be fabricated compared with previously designs limited by inhomogeneity based on transformation optics. To verify the theoretical design, a four-beam antenna constructed with ultrathin, homogenous and uniaxial anisotropic metalens is designed, fabricated and measured. It is shown that the realized gain of the four-beam antenna is increased by 6 dB compared with the single dipole source, while working frequency and relative bandwidth are kept unchanged. The measured far-field pattern verifies theoretical design procedure.

TOP

C_M02 Measurement Topics

Cellular Communications / Regular Session / Measurements

Oral Sessions: Room 342A

Chairs: Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany), Brett Walkenhorst (NSI-MI Technologies, USA)

16:30 ***Thermal Noise Effects of a Simple Correlator for High Dynamic Range Measurements***

Brett Walkenhorst (NSI-MI Technologies)

In order to achieve high accuracy in measuring sidelobes and/or nulls in antenna patterns, it is necessary to use a test system with very high dynamic range. For several years, commercially available antenna measurement receivers have offered a dynamic range as high as 135dB for such applications. This dynamic range has been made possible, in part, by a simple correlator in the receiver's DSP chain. In a previous paper, noise-free signal models were developed and analyzed to demonstrate the correlator's ability to reduce carrier frequency offset (CFO) and local oscillator (LO) phase noise to offer the fidelity of test signal necessary to achieve extremely high dynamic ranges of up to 135dB. Building on those models, this paper models the effects of thermal noise and analyzes situations where the correlator works well and where it negatively impacts performance.

16:50 ***Inverse-Source Algorithm for Antenna-Field Transformations Using the Weak Form of the Combined-Source Condition***

Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany); Thorkild Birk Hansen (Seknion, Inc., USA)

Inverse equivalent-source algorithms for antenna field transformations are particularly powerful and robust if they work with directive sources that radiate primarily from the source region towards the field observation locations. Such directive behaviour can for example be achieved by employing an additional integral equation that explicitly imposes a null-field condition (known also as a Love condition) in the original source region of the antenna. An approximate null-field condition can be achieved in the form of an impedance-boundary condition, which is also known as the combined-source condition. In this work, the combined-source condition is utilized in a weak form, and the directivity of the expansion sources is further increased by shifting the source points into complex space. This inverse source algorithm is formulated and used for near-field to farfield transformations of measured antenna fields. The results are discussed and compared to those achieved with the corresponding strong-form algorithm.

17:10 ***Analysis of Electromagnetic Measurements in Intercomparisons with Low Number of***

Participants

Isabel Expósito (University of Vigo, Spain); Manuel García Sánchez (Universidade de Vigo, Spain); Iñigo Cuiñas (University of Vigo, Spain)

The evaluation of performance represents a critical activity to ensure the quality standards of electromagnetic test labs. Intra- and inter-laboratory measurement campaigns are used for that purpose. However, problems arise when a low number of participants take part in the comparison. We present several intercomparison examples and the difficulties that appear in the data analysis.

17:30 ***A New One-Port S-Parameter Calibration Workflow by Means of a MEMS-based Variable Capacitor Array***

Manuel Kasper, Mykolas Ragulskis and Ivan Alic (Keysight Technologies, Austria); Jorgen Bojer (Wispry Inc., Denmark); Michael Dieudonné (Keysight Technologies, Belgium); Ferry Kienberger (Keysight Technologies, Austria)

One-port reflection calibration is a widely used technique for RF and microwave VNA measurements in a broad range of applications including on-wafer chip testing, production testing, and microwave imaging. Recent developments in the field of antenna tuning components lead to advanced, highly stable MEMS-based variable capacitors. In this study we present the use of an antenna tuning integrated circuit (IC) for realizing a compact and fast transfer standard for one-port calibration. In contrast to traditional Short-Open-Load methods a new workflow that uses different capacitance states was developed. Together with least-squared-error solving this leads to improved calibration performance. Verification against metrology grade standards showed agreement of less than -45 dB vector difference. In addition, an estimation of the expected S-parameter error due to temperature deviations was performed. The new calibration workflow can be used in applications where multiple ports need to be calibrated fast and accurate.

17:50 ***SVO in Array Diagnostic for the Planar Near-Field Scanning***

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

A method for the array characterization from Near-Field measurements is here presented. The method exploit the concept of Singular-Value Optimization to dramatically reduce the number of data needed by a complete mapping of the excitations. The approach is here applied to a planar scanning and numerically validated.

18:10 ***NFC/RFID Benchmark Design and Verification Strategy Against EMVCo Standard***

Yehya Nasser (L'Institut National des Sciences Appliquées de Rennes, France); Hussein Hijazi (Grenoble-INP, GIPSA-Lab, France); Ali Chamas Al Ghouwayel (Lebanese International University, Lebanon)

In this paper, the problem of NFC/RFID technology frontend performance verification is addressed. To make this technology succeeded, it is necessary to test conformance, acceptance, compliance, consistency and interoperability of NFC/contactless infrastructure. Industry bodies such as EMVCo is developing and maintaining programs to ensure device conformance, acceptance, compliance, consistency, and interoperability. Thus, a Test Bench Simulator is proposed, based on a Computer Aided Design tool, which allows flexible, fast and accurate verification strategy for NFC technology designs against complete test plans that are fully compliant with EMVCo NFC/contactless experimental specifications. To verify the proposed design, simulations are carried out and results are compared to the results of particular measurements done by the EMVCo laboratories. All results show a pretty good matching with EMVCo standard. Additionally, in this paper, simulation is conducted using full-wave 3D FEM EM Simulator.

TOP

B_P03 Biological Propagation Measurements

Biomedical / Regular Session / Propagation

Oral Sessions: Room 342B

Chairs: Caterina Merla (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France), Carey Rappaport (Northeastern University, USA)

16:30 ***Dosimetry and Hyperthermia Computation in Human Tissues in Presence of EM-Waves Using TLM Method***

Abdelrahman Ijjeh (University of Nice Sophia-Antipolis & TELECOM Bretagne Institute, France); Oualid Makhlouf (University of Nice Sophia Antipolis & Laboratoire d'Electronique, Antennes et Télécommunications, France); Marylène Cueille (University of Nice Sophia Antipolis CNRS, France); Jean-Lou Dubard (Université de Nice - Sophia Antipolis, CNRS, France); Michel Ney (TELECOM Bretagne Institute, France)

The interaction between electromagnetic waves and complex media and its consequences on other physical phenomena such as hyperthermia is a crucial issue for various types of applications. To name a few, electromagnetic compatibility, microwave ovens design, medical applications, and the design of electromagnetic devices and circuits that include lossy media. In this article, we present a full-wave time-domain TLM-based framework that can handle electromagnetic, thermal and the electromagnetic-thermal coupling scenarios. Some experiments are presented and their results are compared with FIT (Finite Integration Technique).

16:50 ***Continuous Monitoring of Hemorrhagic Brain Strokes via Contrast Source Inversion***

Ismail Dilman (Istanbul Technical University, Turkey); Uğur Yıldırım (Turkish-German University, Turkey); Egemen Bilgin, Semih Dogu, Mehmet Çayören and Ibrahim Akduman (Istanbul Technical University, Turkey)

We consider the differential microwave imaging for continuous monitoring of hemorrhagic brain strokes where our aim is to determine the change of bleeding in sequential time frames. The scattered electromagnetic field is measured in two different time steps, and the difference in the scattered field is used as the data of the inversion scheme. The imaging is performed via contrast source inversion. However, since the data of the inversion scheme consists of the difference of the scattered field measurements, the algorithm produces a differential contrast function instead of a complete reconstruction. This function carries information about the difference in the electromagnetic parameters of the brain, that is the relative size of the blood region, between two measurements. The numerical simulations with a realistic head model demonstrate that the method is capable of detecting changes in multiple blood regions, and provides information about the locations and the types of these changes.

17:10 ***Electromagnetic Exposure Systems for Real Time CARS Imaging***

Caterina Merla (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France); Micaela Liberti (ICEmB at "Sapienza" University of Rome, Italy); Paolo Marracino (Sapienza University of Rome, France); Antoine Azan (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France); Francesca Apollonio (University Sapienza of Rome, Italy); Lluis Mir (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France)

We have developed an optical imaging technique based on the Coherent Anti-Stokes Raman Scattering (CARS) that is going to be used as a way to experimentally explore specific signatures (molecular scale) related to the electromagnetic exposure of single cells. This new experimental configuration combines a wide-field CARS microscope with a wide-band electromagnetic micro-device capable of simultaneously exposing several cells to various electromagnetic waveforms (pulsed or continuous waves). The numerical analyses conducted on three different micro-devices (an edge coupled microstrip line, a coplanar waveguide and a slot line) possibly suitable to be integrated into the CARS microscope are presented.

17:30 ***Alternating FDFD and Born Approximation to Compute Dielectric Properties of Breast Tissue and Localize Anomalous Lesions Using DBT Priors***

Matthew Tivnan (Northeastern University & L2S, CNRS-CentraleSupélec, USA); Carey Rappaport (Northeastern University, USA)

A hybrid technique using Digital Breast Tomosynthesis and Microwave Tomography shows promise for improved contrast with respect to conventional breast imaging modalities. A healthy background field is modeled using a Finite Difference solver with prior geometry given by Digital Breast Tomosynthesis. This background field is subtracted from the measurements to isolate the anomalous portion of the measured signal which is due to the carcinoma. The healthy background geometry used in this simulation is obtained using a characteristic relationship between the mass attenuation coefficient (measured in X-ray images) of healthy tissue and the complex dielectric constant. This relationship can be computed using gradient descent. However, the computationally demanding nature of this inverse problem makes it less desirable for real clinical applications. Proposed herein is an algorithm which uses Born approximation on alternate iterations to decrease computational demand. Preliminary 2D numerical experiments in realistic media show this adjustment decreases the computation time.

17:50 ***Time Domain Complex Radar Cross Section of Human Body for Breath-Activity Monitoring***

Tien Tu Vo (Telecom ParisTech, University of Paris-Saclay & CEA LETI Grenoble, France); Laurent Ouvry (CEA-Leti Minatec, France); Alain Sibille (Telecom ParisTech, France)

The knowledge of the complex Radar Cross Section (RCS) of the human body in ultra-wide band can fully describe the breathing activity. In this paper, we investigate the time domain RCS so as to analyze the backscattered signal from the human body, for further respiratory monitoring in any aspect angle. The time domain RCS measurements are first calibrated with the monostatic radar measurement of a metallic sphere. Subsequently, the RCS of a human body phantom is measured over the full 0-360o angle, azimuth range, allowing to put forward the creeping wave around the body. Finally, we measure the RCS of a human person and its temporal variation, also in various aspect angles. The results, which show a mixture between breathing and other body movements, are valuable inputs for respiratory monitoring in various body postures.

18:10 ***Bio-Electromagnetic THz Propagation Modeling for In-Vivo Wireless Nanosensor Networks***

Hadeel Elayan (Khalifa University, United Arab Emirates (UAE)); Raed Shubair (Khalifa University (KU) & Massachusetts Institute of Technology (MIT), United Arab Emirates (UAE)); Josep M Jornet (University at Buffalo, USA)

Nanosized devices operating inside the human body open up new prospects in the healthcare domain. In vivo wireless nanosensor networks (iWNSNs) will result in a plethora of applications ranging from intrabody health-monitoring to drug delivery systems. With the development of miniature plasmonic signal sources, antennas and detectors, wireless communications among intrabody nanodevices will expectedly be enabled in the Terahertz Band (0.1-10 THz). This result motivates the analysis of the phenomena affecting the propagation of electromagnetic signals inside the human body. In this paper, a rigorous channel model for intrabody communication in iWNSNs is developed. The total path loss is computed by taking into account the combined effect of the spreading of the propagating wave, molecular absorption from human tissues, as well as scattering from both small and large body particles. The overall attenuation model of intrabody THz propagation facilitates the accurate design and practical deployment of iWNSNs.

CS23 Massive MIMO Antenna Technologies and Interference Mitigation Techniques for 5G Networks in the Frequency Bands above 6 GHz

TOP

High Data-rate Transfer / Convened Session / Antennas

Oral Sessions: Room 343

Chairs: Przemyslaw Gorski (ViaSat, Switzerland), Rudolf Zetik (Fraunhofer Institute for Integrated Circuits IIS, Germany)

16:30 ***Antenna Array Configurations for Terrestrial Backhaul Links At Ka-band Frequencies***

Rudolf Zetik (Fraunhofer Institute for Integrated Circuits IIS, Germany); Christian Steinmetz (Ilmenau University of Technology, Germany); Marcus Grossmann and Markus Landmann (Fraunhofer Institute for Integrated Circuits IIS, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany)

The paper considers a backhaul network for Ka-band. In this band, antenna arrays must employ large number of elements with appropriate beamforming techniques to combat the severe path loss. The goal of this paper is to analyze massive antenna arrays under realistic considerations for the use in terrestrial backhaul links. This analysis addresses practical issues from the implementation point of view such as 3D array geometry, the minimum number of radiating elements needed to fulfill link budget requirements in backhaul links, distribution of radiating elements in a 3D array geometry and influence of realistic antenna patterns on beamforming capabilities of such arrays. The results indicate that a realistic backhaul scenario may require antenna arrays containing thousands of radiating elements. Selected simulation examples show that polarimetric beamforming is required in realistic scenarios especially when radiating elements do not have good cross polarization discrimination.

16:50 ***Developments on Phased Array for Low-Cost, High Frequency Applications***

Przemyslaw Gorski (Viasat Antenna Systems SA); Maria Carolina Vigano (Viasat Antenna Systems SA, Switzerland); Daniel Llorens (ViaSat Antenna Systems SA, Switzerland)

This work presents the design and implementation of a phased array antenna for reconfigurable 5G backhaul network links. In order to minimize costs, the antenna has been developed using low cost RO4003 substrates and off the shelf electronic components. The antenna operates in Ka band (19 GHz) with scan range down to 50°.

17:10 ***Null-Steering Reflectarrays for 5G Backhaul Networks Limited by Interference***

Xavier Artiga (Centre tecnològic de Telecomunicacions de Catalunya (CTTC), Spain)

Future 5G backhaul networks in dense small cell deployments will require high gain antennas with beam- and null-steering capabilities. In this framework this paper analyzes the null-steering capabilities of reflectarray antennas, as a low cost alternative to traditional antenna arrays. In particular, a random search algorithm is used to show that null-steering can be performed even with 1-bit reflectarrays, but that the synthesized null-depth and width is much more sensitive to aperture phase errors than the main beam gain. Multi-feed reflectarrays are then proposed to overcome this sensitivity but at the expense of higher system complexity and cost.

17:30 ***Low-Cost Hybrid Analog-Digital Beamformer Evaluation in Spectrum Sharing Systems***

Miguel Ángel Vázquez (Centre Tecnològic de les Telecommunicacions de Catalunya (CTTC/CERCA), Spain); Xavier Artiga (Centre tecnològic de Telecomunicacions de Catalunya (CTTC), Spain); Ana Pérez-Neira (CTTC, Spain)

This paper evaluates different analog-digital beamforming solutions for future spectrum sharing mm-wave scenarios. In contrast to sub-GHz multiantenna schemes where all-digital solutions provide an excellent performance-cost trade-off, in the mm-wave bands where a very large number of antennas is required, all-digital designs cannot be deployed due to their cost and complexity. In order to solve this problem, sub-array solutions are conceived where a reduced number of radiofrequency chains are simultaneously connected to different antennas through an analog beamforming network formed by phase shifters (i.e. with no amplitude control). Different connectivity solutions are evaluated; namely, full-connected, localized and interleaved considering that either the phase shifters have full resolution or only one control bit. As reported in the paper, while for the full resolution case the same performance is obtained for all three connectivity schemes, in case the phase shifters have one control bit, substantial differences show up.

17:50 ***Real-field Performance of Hybrid MISO Time Reversal Multi-beam Beam-former at mm-Waves***

Diego Dupleich (Ilmenau University of Technology, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Robert Müller (TU Ilmenau, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

In the present paper we evaluate the performance of a hybrid digital/analog multi-beam beam-forming architecture with polarization and delay compensation using time reversal (TR). Double-directional, ultra wideband dual-polarized channel measurements at 70 GHz in a conference room have been used to emulate the channel. The use of multiple beams to mitigate human shadowing has been evaluated and the temporal and spatial focusing of time-reversal to reduce inter-user interference.

18:10 ***Partial Update of Antenna Weight in Multiuser MIMO for Time-Variant Propagation Channel***

Tetsuki Taniguchi (University of Electro-Communications, Japan); Yoshio Karasawa (No Affiliation, Japan); Nobuo Nakajima (The University of Electro-communications, Japan)

The performance of multiuser multiple input multiple output (MIMO) downlink communication system is degraded under the assumption of rapid movement of user terminals with a certain speed. Though several methods have been proposed to improve this situation, they consume extra-degrees of freedom for the extension of the zero forcing (ZF) area and/or heavy computational load for the frequent update of weights. This paper presents a low computational design approach based on block diagonalization consuming degrees of freedom smaller than or equal to the minimum required value, where only a subset of transmit weights are updated according to linearly extrapolated channel keeping the zero forcing condition as possible. Computer simulations exhibit that the proposed approach can always show good performance if the adequate weight update parameters are chosen.

R_A02 Antennas for Imaging

TOP

Radars / Regular Session / Antennas
Oral Sessions: Room 352A
Chairs: Valeri Mikhnev (Institute of Applied Physics, National Academy of Sciences, Belarus), Stefania Monni (TNO Defence Security and Safety, The Netherlands)

16:30 ***Performance Comparison of Different Sparse Array Configurations for Ultra-Wideband,Near-field Imaging Applications***

Talat Cetin (Aselsan, Turkey); Lale Alatan (METU, Turkey)

The aim of this study is to compare the performance of different multiple-input multiple-output (MIMO) array topologies, intended to be used in ultrawideband (UWB) near-field imaging applications, by using an analysis method that does not include the effects of image reconstruction algorithm. For this purpose, maximum projection method, previously proposed for the analysis of UWB arrays under far-field conditions, is utilized and modified to obtain two way beam patterns of UWB arrays operating in the near-field. The side lobe levels of these beam patterns are shown to be a clear performance criterion for evaluating the performance of sparse antenna arrays. Numerical simulation results are compared with previously reported results for some commonly used array configurations and a good agreement is observed.

16:50 ***Near and Far Field Focusing Patterns for a 2D Sparse MIMO Array***

Harun Cetinkaya and Simon Kueppers (Fraunhofer-FHR, Germany); Reinhold Herschel (Fraunhofer FHR, Germany); Nils Pohl (Ruhr-University Bochum & Fraunhofer FHR, Germany)

A geometrically simple circular array topology for two dimensional (2D) sparse multiple-input-multiple-output (MIMO) array is proposed. The focusing and imaging properties of the array in the millimeter-wave range with narrow-bandwidth are studied by simulation. The results for the focusing property show that the array has decent sidelobe levels over a wide field of view within near and far field. Imaging capability of the array presents that point-like targets are well reconstructed with a high dynamic range.

17:10 ***Broadband Coaxial Line to Rectangular Waveguide Transition for a Microwave Tomography Sensor***

Malte Mallach and Thomas Musch (Ruhr-Universität Bochum, Germany)

A broadband coaxial line to rectangular waveguide transition for a microwave tomography sensor is presented. It consists of two parts: a coaxial line to double ridged waveguide transition and a double ridged to rectangular waveguide transformer. The transition is well matched (reflection coefficient below -10 dB) and has a low insertion loss (below 3 dB) in a wide frequency range from approximately 0.85 GHz to 4.4 GHz. Due to the symmetric design of the double ridged waveguide, a large single mode propagation bandwidth (0.6 GHz to 3.2 GHz) and a good higher order mode suppression (greater than 10 dB above 3.2 GHz) is achieved. The transition design is described in detail, analyzed by 3D electromagnetic field simulations, and validated by measurements.

17:30 ***High-resolution Imaging and Separation of Multiple Pedestrians Using UWB Doppler Radar Interferometry with Adaptive Beamforming Technique***

Motoshi Anabuki and Shigeaki Okumura (Kyoto University, Japan); Takuya Sakamoto (University of Hyogo & Kyoto University, Japan); Kenshi Saho (Ritsumeikan University, Japan); Toru Sato (Kyoto University, Japan); Mototaka Yoshioka (PANASONIC, Japan); Kenichi Inoue, Takeshi Fukuda and Hiroyuki Sakai (Panasonic Corporation, Japan)

Ultra-wideband (UWB) radar imaging has attracted attention for use in security and intelligent transportation system (ITS) applications. Conventional UWB Doppler interferometry is an effective way to obtain high-resolution images while using a simple radar system. However, this method produces ghost images when multiple closely-spaced human targets are present. To resolve this problem, we propose a new technique that combines UWB Doppler interferometry with an adaptive beamforming method called estimation of signal parameters via rotational invariance techniques (ESPRIT). We also propose a tracking and separation algorithm that uses the k-nearest neighbor method. Through a combination of numerical simulations and measurements, we demonstrate the remarkable performance improvement that can be achieved using our proposed method. The proposed method can separate multiple humans with a root-mean-square error of 5.2 cm, which makes its accuracy 1.9 times higher than that of the conventional method.

17:50 ***A Semicircle Bow-Tie Antenna for Subsurface Radar Applications in Civil Engineering***

Valeri Mikhnev (Institute of Applied Physics, National Academy of Sciences, Belarus); Vitaly Badeev (Institute of Applied Physics, Belarus)

A modified bow-tie antenna consisting of two semicircle flares fed by a tapered microstrip line is described. Such design allows avoiding separate impedance transformers and baluns that are often poorly matched over the wide frequency band of operation resulting in considerable late-time ringing. The tapered microstrip line using one of the antenna flares as ground plane is used to transform 50 Ohm impedance of the feeding cable to the antenna impedance of around 100 Ohm. The antenna performance was tested experimentally using a concrete member made of heavy density concrete with a metal rod inserted near its center. For the sake of comparison, two other antennas designed for the same frequency band, namely tapered-slot Vivaldi antenna and conventional bow-tie antenna with impedance transformer have been tested in the same scenario.

18:10 ***Advanced Design of a Polarimetric X-band Antenna for Avionic Weather Radar***

Giovannni Galgani and Gabriele Scozza (IDS, Italy); Roland Bolt (TNO Defense Safety and

Security); Nadia Haider (TNO Defense Safety and Security, The Netherlands); Stefania Monni (TNO Defense Safety and Security); Francois Delbary (Rockwell Collins, France)

In this work we present the first phase results in the design of a fixed beam dual-polarized antenna at X-band for a polarimetric weather radar to be mounted on aircraft. Such a radar is not yet existent. Requirements pertinent to the application are presented and the different antenna system components described together with their simulated performances. Further steps in the development are anticipated.

L_A04 Wireless Power Transmission and Harvesting I

TOP

Localization & Connected Objects / Regular Session / Antennas

Oral Sessions: Room 352B

Chairs: Davor Bonefačić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia), Adam Narbudowicz (Dublin Institute of Technology, Ireland)

16:30 ***Slot Antenna Design for a Wirelessly Powered Implantable Microcooler for Neuronal Applications***

Hugo Dinis (University of Minho, Portugal); José Fernandes (DEI- University of Minho, Portugal); Paulo Mendes (University of Minho, Portugal)

Implantable medical devices are becoming smaller by the day, with more efficient electronics and smaller power demands. Nevertheless, there are some applications in which power demands are inherently high, and solutions must be found to keep the devices as small as possible. In this paper, we propose an antenna to be used in wirelessly powering a focal brain cooling implant based on a Peltier device. This antenna is designed in order to act as a heatsink for the device with the goal of minimizing its final volume, therefore design constrains such as size limitations and geometry restrictions are considered.

16:50 ***Feasibility of Electromagnetic Energy Harvesting Using Wearable Textile Antennas***

Branimir Ivšić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia); Mateja Babić (University of Zagreb, FER, Croatia); Andrej Galoić and Davor Bonefačić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia)

In this paper the quantity of available environmental electromagnetic energy in typical urban scenario is investigated. Measurements of the EM power density were performed at several indoor and outdoor locations. The findings are applied to estimate the available power on typical wearable textile antenna.

17:10 ***Fully Inkjet Printed Wide Band Cantor Fractal Antenna for RF Energy Harvesting Application***

Azamat Bakytbekov and Armando Rodriguez Maza (King Abdullah University of Science and Technology, Saudi Arabia); Mahmoud Nafe (King Abdullah University for Science and Technology, Saudi Arabia); Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

Energy harvesting from ambient RF signals is feasible, particularly from the GSM bands such as 900MHz,1800MHz and the 3G band at 2.1GHz. This requires a wideband receive antenna which can cover all these bands with decent gain performance and an omnidirectional radiation pattern. In this work, a novel Cantor fractal antenna has been designed which fulfills the above mentioned performance requirements. Antenna has been realized through a combination of 3D inkjet printing of plastic substrate and 2D inkjet printing of metallic nanoparticles based ink. The stable impedance and radiation performance of the antenna over a bandwidth of 0.8GHz to 2.2GHz (93 %) shows the feasibility of its employment in wide band energy harvesting applications.

17:30 ***Analysis of Reactance Compensation for Eliminating Cross-Coupling in Multiple-Receiver Inductive Power Transfer***

Quang-Thang Duong and Minoru Okada (Nara Institute of Science and Technology, Japan)

This paper investigates reactance compensation method to eliminate the impact of cross-coupling in single frequency inductive power transfer (IPT) system with arbitrary number of receivers. Receiver-side resonance loses its optimality in multiple receiver scenarios under the existence of significant cross-coupling among receivers. Therefore, the resonant capacitances are added with compensatory reactances, whose values are analytically optimized for maximizing efficiency based on N-port network model. Cross-coupling eliminating effect of our method is verified by numerical analysis. The results also indicates that as the coupling between the transmitter and the receivers becomes weaker, the impact of cross-coupling becomes more severe, and because of that the reactance compensation becomes more effective.

17:50 ***Oval Double Spiral Coil for High Efficiency Wireless Power Transmission***

Hisao Iwasaki and Shun Hasegawa (Shibaura Institute of Technology, Japan)

We propose the oval double spiral coil for high efficiency wireless power transmission. The high efficient wireless power transmission method is minor axis angle rotation of the receiving oval double spiral coil and offset the receiving oval double spiral coil relative to the transmitting oval coil. The simulated and measured power transmission efficiency results are agreed very well.

18:10 ***Simulation Framework for Performance Evaluation of Passive RFID Tag-To-Tag Communications***

Lin Zhou, Florin Hutu and Guillaume Villemaud (Univ. Lyon, INSA Lyon, Inria, CITI, F-69621 Villeurbanne, France); Yvan Duroc (Univ. Lyon, UCBL, Ampere Laboratory, F-69622

Villeurbanne, France)
The concept of passive RFID tag-to-tag communications has been recently introduced and opens new promising perspectives, especially in the field of Internet-of-Things. In this paper, a simulation framework is proposed as a new tool allowing the performance evaluation of tag-to-tag radio links. The modeling takes into consideration the external source supplying the communication between tags, radiating characteristics of tag antennas, and reception system aspects. Performance results are expressed in terms of Bit Error Rate (BER) with respect to the distance between the tags and the position of the energy source relative to the position of the two tags.

TOP

MT_A02 Computation Techniques

Methods & Tools / Regular Session / Antennas
Oral Sessions: Room 353
Chairs: Ovidio Mario Bucci (University of Naples, Italy), Atef Elsherbeni (Colorado School of Mines, USA)

16:30 ***Coupling Yee Grid to Lebedev Grid in Two-Dimensions***
Mahbod Salmasi and Mike Potter (University of Calgary, Canada); Michal Okoniewski (University of Calgary & Acceleware Ltd, Canada)
The standard Yee grid, though simple and robust, is not well suited to modelling anisotropic media. In contrast, the Lebedev grid is well suited, but is computationally more expensive. A methodology is presented to use classical Yee grid in isotropic regions and take advantage of Lebedev method as a subgridded region for anisotropic materials only. Two methods to couple the two regions are proposed and described in detail. The proposed methods show low reflection in a scenario where a normally incident planewave hits Yee-Lebedev interface. Also, the two techniques are shown to be both accurate and stable.

16:50 ***Analysis of Scattering from Electrically Large Objects Using Fast Far Field Iterative Physical Optics***
Paolo De Vita, Alessandro Mori, Luca Pandolfo, Mirko Bercigli and Mauro Bandinelli (IDS Ingegneria Dei Sistemi S. p. A, Italy); Giorgio Carluccio (Delft University of Technology, The Netherlands); Matteo Albani (University of Siena, Italy)
In this paper, a fast iterative physical optics (FIPO) algorithm is proposed for analysis of scattering from electrically large objects involving multiple reflections. When the scenario to be analyzed is electrically very large, a Fast Far Field Approximation (FaFFA) algorithm, based on a domain decomposition of the scatterer surface, can be conveniently used to greatly speed-up the calculation of the induced currents at each step of the iterative procedure. In this work, an efficient and accurate interpolation scheme has been combined to the standard FaFFA algorithm implementation further reducing the complexity of the computation.

17:10 ***A Stable Marching-on-in-Time Algorithm Capable of Handling Multiple Excitations - Application to Wire Junction Problems***
Sadasiva Rao (Naval Research Laboratory, USA)
In this work, a stable marching-on-in-time method is presented to obtain scattering response from arbitrary wire structures illuminated by a Gaussian plane wave directly in the time domain. Contrary to all the available time domain algorithms till now, the present procedure is also capable of handling multiple excitations in a trivial manner. The new procedure is based on the conventional method of moments and utilizes standard pulse functions for expansion of space and time variables. The testing procedure is accomplished by collocation procedure. The numerical results obtained using the new procedure are validated by comparing with data obtained from frequency domain solution and performing inverse discrete Fourier transform.

17:30 ***Non-uniform Surface Impedance Absorbing Boundary Condition for FDTD Method***
Yunlong Mao (Harbin Engineering University, P.R. China); Atef Elsherbeni (Colorado School of Mines, USA); Si Li and Tao Jiang (Harbin Engineering University, P.R. China)
Surface impedance absorbing boundary (SIABC) has a comparable absorbing performance compared to CPML, but requires a sufficient long distance between the boundary and the scatter. In this paper, we focus on this issue and introduce the non-uniform SIABC. Non-uniform SIABC archives a similar absorbing performance as the uniform SIABC at a same distance, while the number of the air buffer cells is much smaller. Therefore, it is possible for us to make it more efficient relative to uniform SIABC or CPML. An example of a patch antenna is discussed to explore the accuracy and efficiency of non-uniform SIABC. We also compare the memory usage for uniform SIABC, non-uniform SIABC, and 10-layers CPML. All the results indicate that non-uniform SIABC requires much less memory, needs much less time for simulations, which makes it a potential of being one of the most popular ABCs in FDTD method.

17:50 ***Closed-form Evaluation of the Singular Terms in Electric Field Integral Equations***
Denis Tihon (Université Catholique de Louvain & ICTEAM Institute, Belgium); Christophe Craeye (Université Catholique de Louvain, Belgium)
Using Surface Integral Equations, such as the Method of Moments (MoM), the integral of singular or nearly-singular functions over pairs of Basis function (BF) and Testing function (TF) must be evaluated. In particular, the Electric Field Integral Equation (EFIE) requires the integration of the Green's function, which asymptotically behaves as 1/R for source and observation points that are getting closer. In this paper, we provide a closed-form expression of the integral of the 1/R function for triangular BF and TF. The method presented has been made as general as possible, in order to be easily adapted to different geometries.

18:10 ***A Novel FDTD Formulation to Model Dispersive Chiral Media***

Reza Mohammadi-Baghaee (School of ECE, University of Tehran, Tehran, Iran., Iran); Mojtaba Dehmollaian (University of Tehran, Iran); Jalil A. Rashed-Mohassel (School of Electrical and Computer Engineerimg College of Engineering & University of Tehran, Iran)

Wave propagation in a general dispersive chiral media is examined by a direct finite difference time domain (FDTD) technique. Using convolutional integrals directly in time domain without use of transformation techniques such as Z-and Mobius transformations, wave field decomposition is the main idea to drive the FDTD formulation. Time domain permittivity, permeability, and chirality of dispersive materials are found from their frequency domain expressions. These time domain models are used in convolutional terms to model wave propagation in dispersive chiral media. The co- and cross-polarized reflected and transmitted waves from a chiral slab illuminated by a normally incident plane wave are investigated. The results have a good agreement with previous ones using Z-transformation technique.

TOP

CS22 Innovative Antennas for TT&C and PDTM Satellite Links

Space / Convened Session / Antennas

Oral Sessions: Room 362/363

Chairs: Anthony Bellion (CNES, France), Nacer Chahat (NASA-JPL, Caltech, USA)

16:30 ***RUAG Space Activities in the TT&C, GNSS and Data-Downlink Antenna Field***

Jan Zackrisson (RUAG Space AB, Sweden)

This paper presents some of our antenna activities in the TT&C, GNSS and Data-Downlink area. Our involvement in such antenna designs spans over a 40 year period starting in the mid 70ies, first within the antenna group at LM Ericsson and Saab Ericsson, and now at RUAG

16:50 ***New Mechanical Steering Compact Antenna Solutions in X and Ka Band for Payload Telemetry***

Jerome Lorenzo, Benjamin Monteillet and Nicolas Ferrando (Thales Alenia Space, France); Jerome Brossier (Thales, France); Patrick Leconte (Thales Alenia Space, France)

This paper presents new mechanical steering compact antenna solutions under development in Thales Alenia Space (TAS) for X and Ka Band applications dedicated to Payload Telemetry requiring high data rate and wide scan steerable domain. The proposed innovative solutions are based on high performances RF feed assembly including rotary joint. The feed assembly is embedded in a very compact dual reflector geometry which allows to minimize the antenna overall volume including kinematic. The proposed design includes common building blocks between X and Ka band Telemetry applications. The TAS antenna patented design proposed is very competitive and can be also used for Telecoms constellations and Inter Satellite Link applications.

17:10 ***TT&C and Payload Telemetry Antennas for Nanosatellite - Eye-Sat Nanosatellite Program***

Kevin Elis, Maleszka Tomasz and Anthony Bellion (CNES, France)

This paper presents a compact single-feed circularly polarized S-band antenna and a medium gain X-band antenna for Nanosatellite TT&C applications. The S-Band antenna is composed of two crossed dipoles printed on both sides of a substrate, center-fed by a 50Ω coaxial cable. The bandwidth of the antenna is 17% (1.98 - 2.35 GHz) and covers TeleCommand and TeleMetry band. The size of the entire structure including the radome and the satellite interface is 0.58λmin of diameter and 0.081λmin of height where λmin is the wavelength at the lowest frequency. The X-band medium gain antenna is composed of 4 single feed circularly polarized patches fed by a sequential phase rotation network that provides an axial ratio better than 1dB. The bandwidth of the antenna is 11% (7.7 - 8.6GHz) and the gain is better than 12dB in the entire payload telemetry band. The final structure is included in 72.5x72.5x9mm3.

17:30 ***Multimode Reconfigurable Nanosatellite Antenna for PDTM Application***

Ali Siblini (Limoges University, France); Bernard Jecko and Eric Arnaud (XLIM, France)

This paper deals with the design of a new reconfigurable beam antenna used to improve the efficiency of spatial telemetry links on nanosatellite. This agile beam antenna is not built on the well-known array concept: AESA (Agile Electronically Scanned Array) but using a new one called ARMA (Agile Matrix Radiating Antenna) ; Marpem in French

17:50 ***CubeSat Deployable Ka-band Mesh Reflector Antenna Development for Earth Science Missions***

Nacer Chahat (NASA-JPL, Caltech, USA); Jonathan Sauder (NASA-JPL / Caltech, USA); Mark Thomson (NASA-JPL / Caltech, France); Yahya Rahmat-Samii (University of California, Los Angeles (UCLA), USA); Richard Hodges (NASA-JPL / Caltech, USA)

CubeSats are positioned to play a key role in Earth Science, wherein multiple copies of the same RADAR instrument are launched in desirable formations, allowing for the measurement of atmospheric processes over a short, evolutionary timescale. To achieve this goal, such CubeSats require a high gain antenna that fits in a highly constrained volume. This paper presents a novel mesh deployable Ka-band antenna design that folds in a 1.5U (10×10×15cm3) stowage volume suitable for 6U (10×20×30cm3) class CubeSats. Considering all aspects of the deployable mesh reflector antenna including the feed, detailed simulations and measurements show that 42.6 dBi gain and 52% aperture efficiency is achievable at 35.75GHz. The mechanical deployment mechanism and associated challenges are also described, as they are critical components of a deployable CubeSat antenna. Both solid and mesh prototype antennas have been developed and measurement results show excellent agreement with

simulations.

18:10 ***Telemetry X-band Antenna Payload for Nano-satellites***
Rodrigo Manrique (MVG Industries, France); Gwenn Le Fur (CNES, France); Nicolas Adnet (MVG Industries, France); Luc Duchesne (SATIMO, France); Jean-Marc Baracco (Mardel, France); Kevin Elis (CNES, France)
This paper presents a compact X-band antenna with an isoflux radiation pattern and circular polarization. It consists of a miniaturized helix antenna connected to a stripline circuit that provides a sequential rotation feeding. The antenna is arranged over a vertically corrugated ground plane and it has been optimized for a CubeSat 3U nano-satellite platform. Its design, manufacture and results are here presented.

TOP

WG_01 Propagation

WG Meetings & Workshops: Room 313/314
Chair: Thomas Kürner (Technische Universität Braunschweig, Germany)

Tuesday, March 21

Tuesday, March 21, 08:40 - 12:30

TOP

CS02 Additive Manufacturing for Antenna and RF Components

Space / Convened Session / Antennas
Room: Oral Sessions: Auditorium Havane
Chairs: María García-Vigueras (IETR-INSA Rennes, France), Ronan Sauleau (University of Rennes 1, France)

08:40 ***ESA's Recent Developments in the Field of 3D-Printed RF/Microwave Hardware***
Petronilo Martin-Iglesias, Maarten van der Vorst, Johannes Gumpinger and Tommaso Ghidini (European Space Agency, The Netherlands)
Additive Manufacturing (AM) is considered a strategic technology for space applications specifically enabling breakthrough developments of RF hardware. The implementation of AM will allow RF hardware manufacturers to enhance significantly the performance of their products. The assessment of different AM approaches has already started and will consider the whole process chain, including design, material supply, processing, post processing, qualification and verification, and standardization. This paper will present the past and current developments in the field of 3D printing for RF/Microwave hardware. Future activities will also be presented.

09:00 ***Using Additive Manufacturing for Feed Chain and Other Passive Microwave Components***
Paul Booth (Airbus Defence and Space Ltd., United Kingdom); Richard Roberts (Airbus Defence and Space Ltd, United Kingdom); Michael Szymkiewicz and Christian Hartwanger (Airbus DS GmbH, Germany)
This paper describes the use of additive manufacturing to realise satellite feed chain and other waveguide components. The advantages and drawbacks of different processes are discussed and examples of components and their performance are presented. A number of the presented components exploit the inherent geometric freedom of additive manufacturing. The near term outlook and ongoing development activities of additive manufacturing at Airbus Defence and Space conclude the paper.

09:20 ***Manufacturing of Waveguide Components for SatCom Through Selective Laser Melting***
Oscar Peverini (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT- CNR), Italy); Mauro Lumia (CNR, Italy); Flaviana Calignano and Diego Manfredi (IIT, Italy); Giuseppe Addamo (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT-CNR), Italy); Massimo Lorusso and Elisa Ambrosio (IIT, Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Paolo Fino (IIT, Italy); Riccardo Tascone (Istituto di Elettr. e di Ingegneria dell'Inform. e delle Telecom. (IEIIT- CNR), Italy)
This paper presents the developments at CNR-IEIIT and IIT concerning microwave waveguide components manufactured through selective laser melting (SLM). The latter is an additive manufacturing process based on the selective melting of a metal powder bed through a laser. Application of this technology to the development of antenna-feed chains aimed at satellite communication (SatCom) is discussed. Description of the process and experimental activities for the assessment of the electromagnetic properties of parts are reported. Measured performance of Ku/K-band filters and Ku-band feed-horns manufactured through SLM will be presented. The results achieved prove that SLM can be a valuable technology both to develop novel components and to increase system integration.

09:40 ***A Study of the Additive Manufacturing Technology for RF/Microwave Components***

Adrian Gomez and Fernando Teberio (Public University of Navarra, Spain); Aitor Martinez (ANTERAL, Spain); Jon Percaz (Public University of Navarra, Spain); Israel Arnedo (Public University of Navarre, Spain); Itziar Maestrojuán (Anteral, Spain); Ivan Arregui (Public University of Navarre, Spain); Gonzalo Crespo (Anteral, Spain); Txema Lopetegi and Miguel Laso (Public University of Navarre, Spain); Jorge Teniente (Public University of Navarra & Institute of Smart Cities, Spain)

In this work an overview of the different Additive Manufacturing techniques will be presented. Each technique will be compared in terms of dimensional accuracy, surface roughness, and quality taking into account the most suitable applications for each one. Then, two applications will be studied: (a) fast prototyping of waveguide component designs using profesional grade 3D printers for electromagnetic validation purposes, and (b) 3D printing of waveguide hardware products as a production technology using production grade 3D printers. The first application will be studied with a research center approach, where many different designs are manufactured in order to validate a design technique or a model. The second application will be studied a with a company approach, where the best quality at a lower price is pursued.

10:00 ***Electrical Tests of Ka Band Input Filters for Space Applications***

Monica Martinez Mendoza, Santiago Sobrino and Ana Isabel Daganzo (Thales Alenia Space, Spain); Tomislav Debogovic, Mirko Favre and Emile de Rijk (SWISSto12 SA, Switzerland)

In this paper, the fabrication of Ka band input filters by means of additive manufacturing technology is tested for space applications. Measurements of manufactured prototypes against recurrent filters designed with specifications used in real satellite communication systems are performed, and conclusions about the potential of the additive manufacturing technology for space applications are stated.

10:20 Coffee Break

10:50 ***3D-Printed Quasi-Optical Antenna-Systems for Mm-wave Communications***

Aimeric Bisognin (University Nice Sophia-Antipolis & STMicroelectronics, France); Diane Titz (University Nice Sophia Antipolis, France); Cyril Luxey (University Nice Sophia-Antipolis, France); Frédéric Gianesello (STMicroelectronics, France); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal); Daniel Gloria (STMicroelectronics, France); Carlos Del-Río (Public University of Navarra & Antenna Group, Spain)

The rapid growth of wireless data drives the development of new technologies. We have here in mind the current works on 5G standardization, wireless backhaul developments in V/E Band as well as low orbit mobile satellite service development in Ku band. For all those communication systems, the availability of high performance and cost effective antenna is key. To address this need, fundamental enablers lie in manufacturing technologies able to handle complex 3D shape while providing at the same time fast and low cost prototyping as well as the ability to support volume production. This paper illustrates how 3D printing and digital manufacturing technologies might help to develop innovative and cost effective antenna solutions in order to address new business challenges. Index Terms — 3D printing, digital manufacturing, antenna, millimeter waves, 5G, Ku band, low orbit satellite, backhaul.

11:10 ***3D-printed Ka-band Waveguide Array Antenna for Mobile SATCOM Applications***

Frédéric Bongard, Martin Gimersky, Stephen Doherty, Xavier Aubry and Mikael Krummen (Viasat Antenna Systems SA, Switzerland)

Purely passive, mechanically steered waveguide-fed horn arrays are good candidates to satisfy the current need for low-to-medium-profile antennas for mobile user terminals for SATCOM applications. In this work, a unique waveguide feed architecture is proposed, which enables the realization of grating lobe-free, wideband, low-profile waveguide-fed horn arrays operating with dual circular polarization. The realization of such structures using 3D printing is investigated, showing the promise of such techniques in terms of design flexibility. To demonstrate the potential of the proposed waveguide array architecture combined with 3D printing, an 8-by-8 antenna array operating in the 20 GHz SATCOM Ka band has been developed and is presented. This antenna exhibits an aperture efficiency of about 80% over a relative bandwidth larger than 10%.

11:30 ***Polymer-Based Metal Coated Additive Manufactured V- And W-band Antenna Feed Chain Components***

Esteban Menargues (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland); Mirko Favre (SWISSto12 SA, Switzerland); Alexandros I. Dimitriadis (Ecole Polytechnique Fédérale de Lausanne & SWISSto12 SA, Switzerland); Santiago Capdevila (EPFL & École Polytechnique Fédérale de Lausanne, Switzerland); Tomislav Debogovic (SWISSto12 SA, Switzerland); Juan R Mosig (Ecole Polytechnique Federale de Lausanne, Switzerland); Maarten van der Vorst (European Space Agency, The Netherlands); Emile de Rijk (SWISSto12 SA, Switzerland)

In this paper an additive manufactured (AM) W-band monolithic feed chain is presented. The feed chain, which consists of a corrugated horn antenna and a turnstile orthomode transducer (OMT), operates over the entire W-band (75 – 110 GHz) and fulfills typical EM specifications for space applications (RL > 20 dB, IL < 1 dB and Xpol < −30 dB). Both the OMT and the horn have been designed by exploiting the design freedom offered by AM, but also taking into account its specific technological constraints. The presented W-band design can be straightforwardly scaled to V-band.

11:50 ***3D-printed Ka-band Antenna Based on Stereolithography***

Joana S. Silva (Huber+Suhner & LEMA-EPFL, IT-IST, Switzerland); María García-Vigueras (IETR-INSA Rennes, France); Tomislav Debogovic (SWISSto12 SA, Switzerland); Juan R Mosig (Ecole Polytechnique Federale de Lausanne, Switzerland)

This paper presents a circularly-polarized dual-band antenna for Ka-band satellite communications which operates

simultaneously in both civil and military downlink (17.7-21.2 GHz) and uplink (27.5-31 GHz) bands. The antenna is composed of a metallic ridged cavity that is perforated with a crossed-slot. This cavity is excited in sequential rotation through four feeding coaxial cables, thus producing circular polarization (CP). The required feed distribution is obtained by a dedicated beam-forming network (BFN) able to provide phases to generate right/left-handed CP in the downlink/uplink-bands, respectively. The prototype of the antenna cavity is 3D printed basing on stereolithography (SLA), while the BFN is realized in printed circuit technology. Good agreement is obtained between theoretical and measured results, thereby validating the antenna concept and confirming the strong potential of SLA to conceive compact RF components.

12:10 ***Innovative Materials and Fabrication Process to Develop New RF Components and Concepts***

Cyrille Menudier (XLIM - UMR CNRS 7252 - University of Limoges & Antennas & Signals, France); Marc Thevenot (XLIM-UMR CNRS 7252, University of Limoges, France); Laure Huitema (Xlim Laboratory, France); Eric Arnaud (XLIM, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Olivier Tantot (XLIM - University of Limoges, France); Stéphane Bila (XLIM UMR 7252 Université de Limoges/CNRS, France); Nicolas Delhote (XLIM - UMR CNRS, University of Limoges, France)

Recent developments on materials for additive manufacturing and associated fabrication process offer new opportunities for the design of antennas and RF components. In this paper, different technologies used by our laboratory are presented and their application to different types of antennas and microwave components, especially filters, is shown. A brief overview of the advantages of such technologies for joint-design and original architectures is also presented.

Tuesday, March 21, 08:40 - 10:20

W_A01 Adaptive & Reconfigurable Antennas for Wireless Networks

TOP

Wireless Networks / Regular Session / Antennas

Oral Sessions: Room 341

Chairs: Stefan Lindenmeier (Universität der Bundeswehr, Germany), Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

08:40 ***Switched Beam Patch Array Antenna Using SPDT GaN HEMT Switches***

Abdelaziz Hamdoun (University of Rennes 1, France & IETR, Canada); Mohamed Himdi (Université de Rennes 1, France); Olivier Lafond (IETR, France); Langis Roy (Carleton University, Canada)

In this paper, a single-fed four-panel 4x1 patch array antenna operating at 2.43 GHz with switched beam capability is proposed. The design allows the beam to be switched between four discrete directions giving 360° coverage. The antenna beam is switched over the azimuth plane for Φ = 0°, Φ = 90°, Φ = 180°, and Φ = 270°. The beam control is achieved by using GaN-based HEMT SPDT switches. Only three SPDT switches are integrated directly into the structure, allowing its nature to be electrically controlled over the desired four directions. Simulated and measured reflection coefficients and radiation patterns for the four cases are presented and discussed, showing good agreement. The antenna gain is around 3.8 dB including switches losses at 2.43 GHz.

09:00 ***A Wideband Automotive Antenna for Actual and Future Mobile Communication 5G/LTE/WLAN with Low Profile***

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

For integration into flat mounting volumes in cars a new wideband antenna is presented covering all frequency bands for cell phone LTE and 5G starting with the LTE low band at 698 MHz up to the WLAN frequency bands at 6 GHz. The performance of the antenna is shown by way of measurement and simulation as a single part and via measurement of an antenna pair in a car on a turntable regarding mutual coupling and influences of the mounting environment. It can be shown that for all the considered frequency bands the gain of the wideband antenna is deviating by only around 2.5 dB from the gain of a set of monopole antennas which are ideally matched for the different frequency bands.

09:20 ***Technique to Increase Directivity of a Reconfigurable Array Antenna for Wireless Sensor Network***

Akimu Dihissou (Université Côte d'Azur & LEAT, France); Aliou Diallo (University of Nice, France); Philippe Le Thuc (University of Nice & UNS-CNRS-LEAT, France); Robert Staraj (University of Nice-Sophia Antipolis, France)

In this paper, a technique to maximize the directivity of an antenna array is presented. It consists of a fed monopole and a loaded parasitic one. The nature and value of the load are obtained using the Uzkov equations that calculate the current weighting coefficients in the case of two separately fed antennas to maximize the gain and the directivity in one direction. Reconfigurability is achieved by using reflectors and directors activated by pin diodes to reduce the back radiation and pointing in the desired direction. Thus a system of two elements, one fed and the other loaded with an inductor, having a maximum gain of 5.2 dBi at 2.45GHz in azimuthal directions 90° and 270° is obtained. The system is compared with a system of two antennas fed separately.

09:40 ***Wideband U-Slot Patch Antenna with Reconfigurable Radiation Pattern***

Jie Wang, Jiexi Yin, Haiming Wang, Chen Yu and Wei Hong (Southeast University, P.R. China)

A wideband U-slot patch antenna with reconfigurable radiation pattern is investigated. The antenna composes three patches which are one coaxial-fed U-slot driven patch and two parasitic patches located near the two non-radiating edges of the middle driven patch. One varactor diode is installed in middle of each parasitic patch. Both beamwidth and main lobe direction can be tuned by controlling the direct current bias voltages of the two varactor diodes. The presented antenna has wide operating bandwidth of 6.4% at 1.4 GHz. Its beamwidth can be continuously changed from 60 degree to 130 degree and its main lobe direction can scan from -20 degree to +20 degree in the H-plane. Its peak antenna gain is 8.8 dBi with gain variation of 3.5 dB along the entire beamwidth tuning range and 8.5 dBi with gain variation of 2.5 dB along the entire beam scanning range. Simulation and measurement results agree well.

10:00 ***Further Investigations on the Behavior of a Frequency Reconfigurable Antenna Cluster***

Jari-Matti Hannula and Jari Holopainen (Aalto University School of Electrical Engineering, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

A recently published paper presented a novel concept for obtaining frequency reconfigurable behavior by combining multiple antenna elements and weighting the feed signals for each element. In this paper, we clarify some concepts presented in that paper and analyze the antenna structure in more detail.

Tuesday, March 21, 08:40 - 12:30

C_M01 MIMO measurements

TOP

Cellular Communications / Regular Session / Measurements

Oral Sessions: Room 342A

Chairs: Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France), Michael Jensen (Brigham Young University, USA)

08:40 ***Cavity Modes Inside a Mode-Stirred Reverberation Chamber Extracted Using the Matrix Pencil Method***

Francois Sarrazin (University of Paris-Est-Marne-la-Vallée & ESYCOM, France); Elodie Richalot (Université Paris-Est (Marne-la-Vallée), France)

This paper presents the extraction of the modes resonating inside a mode-stirred reverberation chamber using the Matrix Pencil method. An increasing time-window technique is investigated as a process to discriminate the true modes and the spurious ones that appear due to the measurement noise.

09:00 ***Over-the-Air Testing of LTE-Advanced Features Using Reverberation Chamber***

Christian Lötbäck, Anton Skårbratt and Klas Arvidsson (Bluetest AB, Sweden)

The 4G standard is constantly evolving with more features being added to the standard specifications. Carrier aggregation and higher order MIMO are examples of features used to support higher data rates. The addition of features puts new requirements on wireless devices and this increasing complexity implies that Over-the-Air testing is more important than ever. At the same time it is important to keep the complexity of test setups to a minimum and to reduce measurement time, given the constant addition of new test cases. This paper elaborates on the RC as a fast, accurate and comprehensive Over-the-Air testing environment for assessing advanced features of state-of-the-art wireless devices. It is shown that a number of different testing scenarios can be realized with one test chamber using time efficient measurement algorithms. This test chamber can also be used for legacy standards and for assessing traditional metrics for antenna and wireless device performance.

09:20 ***Base Station Over-the-Air Testing in Reverberation Chamber***

Christian Lötbäck and Klas Arvidsson (Bluetest AB, Sweden); Mats Högberg and Mattias Gustafsson (Huawei Technologies Sweden AB, Sweden)

This paper elaborates on the feasibility of the reverberation chamber for base station Over-the-Air testing. Several key parameters are measured and compared to results from conducted testing, showing that the metrics currently measured in conducted mode can be translated to Over-the-Air metrics with high accuracy. In addition, an analysis of major uncertainty contributions is provided. This analysis shows that there is insignificant impact on the measurement accuracy when measuring antennas with high gain in the reverberation chamber.

09:40 ***Gradient Ascent Based Optimization for a Reconfigurable OTA Chamber***

Matthew Arnold (Brigham Young University, USA); Rashid Mehmood (Wavetronix LLC, USA); Michael Jensen (Brigham Young University, USA); Jon Wallace (Lafayette College, USA)

A reconfigurable over-the-air chamber represents a reverberation chamber whose walls are lined with antennas that are terminated in reconfigurable impedances, allowing synthesis of a wide range of channel conditions for over-the-air testing of mobile wireless devices. While these chambers have potential for practical device testing, finding the right impedances to achieve the desired channel characteristics remains a challenging problem. This work explores the use of a simple gradient ascent optimization algorithm to determine the impedance states that achieve a specified spatial structure in the multipath, as characterized by the multipath power angular spectrum. The results highlight that the optimization is effective for synthesizing a desired power angular spectrum with a directive peak and a relatively low sidelobe level.

10:00 ***Semi-Omnidirectional Dual-Polarized Wideband Multiport Antennas for MIMO Applications in Random-LOS and RIMP***

Sadegh Mansouri Moghaddam, Andrés Alayon Glazunov and Jian Yang (Chalmers University of Technology, Sweden); Mattias Gustafsson (Huawei Technologies Sweden AB, Sweden)

We present two configurations of multiport antennas for Multiple-input Multiple-output (MIMO) application. The configurations are comprised of three and four dual-polarized selfgrounded bowtie antenna as the element, respectively. The MIMO performance of both antennas is evaluated in Random Line-of-Sight (Random-LOS) and Rich Isotropic Multipath (RIMP) channel models as two edge propagation environments. Both configurations provide 360 azimuth and 120 elevation angular coverage in Random-LOS and full sphere coverage in RIMP. Using digital threshold receiver model and Zero-Forcing receiver, the performances of both configurations are evaluated in terms of Probility of Detection (PoD) and MIMO multiplexing efficiency calculated at 95% PoD level. The simulated results show a good performance for both structures in two edge environments, which can be concluded as a good performance in a real life situation.

10:20 Coffee Break

10:50 ***A 3-D Wide- Band Setup for Over-The-Air Test in Anechoic Chamber***

Mounia Belhabib and Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France); Bernard Uguen (University of Rennes I, France)

In this paper we present a 3D wide-band measurement bench for Over-the-Air (OTA) tests. The setup is composed by twelve double-polarized antennas, placed around the Zone Under Test (ZUT), on three different elevation planes. A characterization of the ZUT was performed in order to assess the differences, in terms of amplitude and phase of the incident field, according to the frequency considered.

11:10 ***MIMO Antenna Performance Assessment Based on Open Source Software Defined Radio***

Cyril Buey (Orange Labs); Theoni Magounaki (Orange Labs, France); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Philippe Ratajczak (Orange Labs, France); Leonardo Lizzi (Université Côte d'Azur, CNRS, LEAT, France); Florian Kaltenberger (Eurecom, France)

This paper presents a low-cost measurement method for MIMO antenna performance assessment based on the open-source initiative OpenAirInterface. A first measurement is presented with a prototype with 8 antennas at 2.5GHz integrated into a 140*140x40mm femto cell and using Laser Direct Structuring (LDS) technique. The setup is validated trough a beamforming gain measurement in a MISO 4x1 configuration in LTE TDD mode.

11:30 ***The Variation of Clusters with Increasing Number of Antennas by Virtual Measurement***

Chao Wang and Jianhua 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); Mengmeng Liu (Beijing University of Posts and Telecommunications, P.R. China); Ye Wu (Huawei Technologies, P.R. China)

This paper shows the variation of clusters with the increasing number of antennas. The data was collected from the massive MIMO mobile measurement at 3.5 GHz, in line of sight (LoS) and non line of sight (NLoS) conditions, respectively. And the virtual measurement method is used to form the 64-element, 128-element and 256-element virtual antenna array from the 32-element antenna array. After estimating parameters by the space-alternating generalized expectation maximization (SAGE) algorithm and clustering by KPowerMeans algorithm, the parameters of clusters are displayed in angular domain and delay domain. The cluster-level angular power spectrums (APS) are shown, the intra-cluster angular spread (AS) and intra-cluster delay spread (DS) of these 4 groups of data are calculated, to display the clusters' variation when antenna number increases.

11:50 ***Antenna Mutual Coupling Effect on MIMO-OFDM System in the Presence of Phase Noise***

Xiaoming Chen (Qamcom Research & Technology AB, Sweden); Shuai Zhang (Aalborg University, Denmark)

This work investigates the antenna mutual coupling effect on multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) systems with oscillator phase noises. Since the antenna correlation when taking the mutual coupling effect into account is smaller than that when the mutual coupling effect is omitted, it is shown that, at small antenna separations, the error rate performance of the MIMO-OFDM system when taking the mutual coupling effect into account can be smaller than that when the mutual coupling effect is not considered (even though the mutual coupling degrades the antenna radiation efficiencies and mismatches). It is also shown that, with sufficient subcarrier spacing, the phase noise effect can be mitigated by simple phase noise compensation regardless of the antenna correlation or mutual coupling.

12:10 ***5G Communications in High Speed and Metropolitan Railways***

Ana Gonzalez-Plaza (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Juan Moreno (Universidad Politécnica de Madrid, Spain); Iñaki Val, Aitor Arriola and Pedro Rodriguez (IK4-IKERLAN, Spain); Florentino Jimenez (Universidad Politécnica de Madrid, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain)

Railway transportation is increasing very fast in all countries, and as a consequence new railways demand high quality communications for control and signaling of trains, as well as high capacity communications for passengers. However, current communications systems cannot provide these services, so 5G systems will be needed to replace old GSM-R and dedicated systems for railway signaling. Also, 5G terrestrial and satellite technologies will provide high data rate services to passengers. In this paper we describe the main characteristics and requirements for critical and non-critical communications in railways. Results are useful to choose the communications technologies

that can fulfill these requirements in the near future.

CS05 Advances in Electromagnetic Diagnostics and Biomedical Sensors

TOP

Biomedical / Convened Session / Propagation
Oral Sessions: Room 342B
Chairs: Sandra Costanzo (University of Calabria, Italy), Yang Hao (Queen Mary University, United Kingdom)

08:40 ***Loss Tangent Effect on the Accurate Design of Microwave Sensors for Blood Glucose Monitoring***

Sandra Costanzo (University of Calabria, Italy)

The effect of loss tangent variation is properly faced in this work for the accurate design of microwave sensors to be applied in the non-invasive monitoring of blood glucose. Bio-antenna optimization is performed by accurately considering the complex permittivity variation of the biological radiation medium. At this purpose, preliminary dielectric data are experimentally collected by using a standard open-ended coaxial probe. Then, the above complex dispersive data are exploited to optimize the antenna dimensions. Return loss measurements on water-glucose solutions with different concentrations are reported to prove the strong enhancement in the prediction of the resonant shift due to the variation of glucose level, when properly considering the loss tangent variation. Preliminary simulation results on blood are also reported.

09:00 ***Dosimetric Characterizations of Electromagnetic Fields Exposures for Biomedical Applications***

Delia Arnaud-Cormos, Sylvia M Bardet and Rodney O'Connor (University of Limoges, CNRS, XLIM, France); Philippe Leveque (University Limoges, CNRS, XLIM, France)

This paper illustrates advances in dosimetry techniques for the characterization of biological entities exposed to electromagnetic fields. Specific developments for the exposure of cancer cells and tumors to pulsed electric fields are introduced. Experimental and numerical technics for the investigations of pulses with durations in the nanosecond domain (nsPEF) and intensities up of a few tens of MV/m are presented.

09:20 ***Exposure Limits and Dielectric Contrast for Breast Cancer Tissues: Experimental Results Up to 50 GHz***

Andrea Martellosio, Pedro Espin-Lopez, Marco Pasian, Maurizio Bozzi, Luca Perregrini, Andrea Mazzanti and Francesco Svelto (University of Pavia, Italy); Massimo Bellomi, Lorenzo Preda, Giuseppe Renne and Paul Summers (European Institute of Oncology, Italy)

At microwave and mm-wave frequencies, the interactions of the human tissue with electromagnetic fields depend on the dielectric properties of the tissue itself. The knowledge of these properties of healthy and malignant tissues, beyond to be crucial in several biomedical applications, is necessary to fix the safety thresholds in policy-making and the exposure limits for the human body. In particular, breast tissues are of particular interest due to the relatively large diffusion of breast cancer. In literature, experimental data are available up to 20 GHz, consequently at mm-wave frequencies they are only derived from extrapolations. This paper presents a feasibility study based on the experimental results of a dielectric characterization of breast tissues. Two main aspects are addressed. First, the contrast achievable between normal and tumorous tissues, a key parameter for several biomedical applications. Second, the compliance of a mm-wave imaging system for breast cancer detection with the ICNIRP recommendations.

09:40 ***Towards 3D Field Intensity Shaping for Biomedical Applications***

Domenica A. M. Iero (Università Mediterranea di Reggio Calabria, 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)

3D field shaping is a canonical problem in wave physics that could impact next generation of therapeutic systems. In this framework, we present an innovative and effective strategy that relies on the convex relaxation of the original NP hard problem by taking inspiration from the optimal constrained power focusing method. The formulation presented in this paper in terms of convex programming allows an efficient solution of the problem at hand by means of local search algorithms.

10:00 ***Feasibility Assessment of a Banach-Space Inversion Procedure for Biomedical Applications***

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

An approach for microwave imaging of hemorrhagic brain strokes is proposed in this paper. The developed procedure is based on the solution of the electromagnetic inverse-scattering problem by using a Newton-scheme developed in the framework of the Lp Banach spaces. Preliminary numerical results, aimed at evaluating the feasibility of the developed approach for brain stroke detection, are reported.

10:20 Coffee Break

10:50 ***Microwave Tomographic Image Improvement by Fitting to a Cole-Cole Relaxation Model***

Tomas Rydholm, Andreas Fhager and Mikael Persson (Chalmers University of Technology, Sweden); Paul M Meaney (Dartmouth College, USA)

We have reconstructed microwave tomographic images of the Supelec breast phantom using our imaging fixture in combination with a multi-channel vector network analyzer. During this study we were able to recover images without the support of a priori information over a broad frequency range - 1100-1900 MHz. We then fitted the spectral values at each pixel within the field of view to a Cole-Cole curve and extracted the coefficients at each location. While the individual images at each frequency provided reasonably representations of the target permittivity and conductivity distributions, the fibroglandular features were generally quite blurred with the surrounding adipose region. However, several of the Cole-Cole coefficient plots provided a higher level of resolution for the inclusions. While there was a noticeably high level of artifacts outside of the breast phantom perimeter, the internal structures are quite representative of the target.

11:10 ***Radio Telemetry Performance of Liver Implanted Ultra Wideband Antenna***

Pongphan Leelatien, Koichi Ito and Kazuyuki Saito (Chiba University, Japan); Akram Alomainy (Queen Mary University of London, United Kingdom); Manmohan Sharma (Nanyang Technological University, Singapore); Yang Hao (Queen Mary University, United Kingdom)

This paper considers a liver implanted antenna and its associated radio telemetric channel using ultra wideband (UWB) technology. The performance of both the implant antenna and the radio channel is evaluated numerically and experimentally using human equivalent multilayer phantom to obtain S-parameter results within the 4-8 GHz band for various distances between the implanted antenna and a body-worn one. The results show a strong potential in using UWB range for such wireless implant communication scenarios and for the intended applications.

11:30 ***Composite Aircraft Lightning Strike Protection Damage Evaluation Using Microwave Microscopy Techniques***

Leandro Rufail (Polytechnique Montreal, Canada); Jean-Jacques Laurin (Ecole Polytechnique de Montreal, Canada); Fidele Moupfouma (Bombardier Aerospace, Canada)

We are presenting a new application of microwave microscopy for the diagnostic of the lightning strike protection mesh used in composite aircraft skin. With this new approach it is possible to resolve defects as small as one cut strand under the paint. We also discuss its ability to measure the paint thickness.

11:50 ***On-Body Skin Confined Propagation for Body Area Networks (BAN)***

Qiang Zhang (University of Pierre and Marie Curie UPMC, France); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France); Luca Petrillo (Université Libre de Bruxelles, Belgium); Philippe De Doncker (ULB, Belgium); Aziz Benlarbi-Delaï (Sorbonne Universités, UPMC Paris 06, France)

The augmenting need for remote monitoring and treating patients by biophysical sensors interconnected via Body Area Networks (BAN) has recently called researchers' attention. The private and confidential transferred data in such application require high information security. One of the solutions is to use human body as a transmission channel. The body surface-confined transmission restricts the off-body detection, increasing the system security. Also, it reduces the interference between BAN users. For better understanding the body channel propagation mechanism, a lossy multilayered human body model, made of skin, fat, muscle tissues, is established for numeric analysis in this paper, using complex frequency dependent dielectric property for each tissue. Transverse Resonance Method is applied to calculate dispersion and attenuation in the propagation direction up to 60GHz. Since the tissue thickness varies with different localization and different person, 3 skin thicknesses, typically 0.5 mm, 1 mm, and 1.5 mm, are considered and compared.

12:10 ***Determination of Complex Permittivity of Arbitrarily Shaped Homogenous Materials via Waveguide Measurements***

Ahmet Aydoğan (Marmara University & Istanbul Technical University, Turkey); Funda Akleman and Serkan Şimşek (Istanbul Technical University, Turkey)

In this study, complex permittivity of arbitrarily shaped homogenous materials loaded in different shaped waveguides (rectangular waveguide and circular waveguide) is determined through an iterative inverse algorithm. S-parameters are calculated for chosen material numerically via Method of Moments (MoM), in place of real measurement data for sake of testing algorithm as a first step. Inverse algorithm depends on calculating transmission-reflection coefficients (two port S-parameters) with respect to updated complex permittivity, started with an initial guess. At each step, calculated S-parameters (either S11 and/or S21) can be used to update complex permittivity in sense of Newton-Raphson numerical approach. Problem is reduced to finding the roots of iterative equation, which is a function of complex permittivity.

CS25 Mm- and THz- wave Propagation Measurements and Modelling for Ultra-high Data Rate Communications (COST CA15104 IRACON)

TOP

High Data-rate Transfer / Convened Session / Propagation

Oral Sessions: Room 343

Chairs: Claude Oestges (Université Catholique de Louvain, Belgium), Alenka Zajic (Georgia Institute of Technology, USA)

08:40 ***Design and Calibration of a Double-directional 60 GHz Channel Sounder for Multipath Component Tracking***

Ruoyu Sun (National Institute of Standards and Technology, USA); Peter Papazian and Jelena

Senic (NIST, USA); Yeh Lo (NTIA, USA); Jae-Kark Choi (National Institute of Standards and Technology, USA); Kate A. Remley and Camillo Gentile (NIST, USA)

The 60 GHz band is being considered for many high-bandwidth wireless applications. To support standards development for these applications, NIST has developed an untethered 60 GHz, 8×16 MIMO channel sounder. It employs a pseudorandom bit sequence with a bandwidth of 4 GHz. The sounder can precisely measure radio propagation channel characteristics such as path loss, small-scale fading, delay dispersion, absolute delay, angle-of-arrival (AoA), angle-of-departure (AoD), and Doppler power spectrum. Its ability to measure the time dynamics of the millimeter-wave radio channel, when untethered and in motion, is unique. It employs electronically-switched MIMO antenna arrays, a robot for moving measurements and an automated one-dimensional positioner for precision measurements at fixed locations. Sounder performance is improved by use of pre-distortion filters and precision calibration of the RF and timing systems. Data showing initial AoD and AoA estimation error are presented along with initial test results for ground-plane reflection.

09:00 ***Polarimetric Analysis of Reverberation Times for 94 GHz Indoor Communication***

Brecht Hanssens (Ghent University, Belgium); Maria Teresa Martinez-Ingles (University Centre of Defence at the Spanish Air Force Academy, MDE-UPCT, Spain); Emmeric Tanghe (Ghent University, Belgium); David Plets (Ghent University - iMinds, Belgium); Jose-Maria Molina-Garcia-Pardo (Universidad Politécnica de Cartagena, Spain); Claude Oestges (Université Catholique de Louvain, Belgium); Luc Martens (Ghent University, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper presents a measurement-based analysis of both the specular- and dense multipath components (SMC and DMC) at 94 GHz in an indoor environment. A total of 15 positions were measured with a virtual antenna array system, from which we have calculated Power Delay Profiles (PDP). A method was developed that allowed for the full-polarimetric estimation of the specular propagation paths, after which the remainder was regarded as the diffuse spectrum. The behavior of the reverberation time, known from the theory of room electromagnetics, was analyzed based on this diffuse spectrum.

09:20 ***A Comparison of Indoor Channel Properties in V and E Bands***

Aliou Bamba (CEA-LETI & Université Grenoble-Alpes, France); Francesco Mani (Università degli studi di Bologna, Italy); Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

This paper presents wideband channel measurements in an office environment in the 62 GHz and 83 GHz frequency bands. Measurements were performed with a VNA and the mechanical steering of directive antennas at both the transmitter and receiver side, allowing a double-directional angular characterization. A comparison of propagation characteristics such as the path loss, multipaths clusters' dispersion properties in the delay and angular domains are provided. Results show that similar propagation characteristics are attainable in the two bands considered.

09:40 ***11 GHz Band MIMO Channel Characteristics in a Street Micro-Cell Environment***

Kentaro Saito and Jun-ichi Takada (Tokyo Institute of Technology, Japan); Minseok Kim (Niigata University, Japan)

Recently, the fifth-generation mobile communication system (5G) has been widely investigated to accommodate increasing mobile users' traffic. In the 5G system, although the utilization of the higher frequency band above the 6 GHz band is expected, the detailed investigation for the applicability to the mobile communication is still necessary because of different radio channel characteristics compared with microwave bands. In this paper, 11 GHz band MIMO channel measurements were conducted in a street micro-cell environment. The result shows that the delay and the angular spreads of the specular paths were smaller compared with the results in the microwave band. The scattered signal component was weak compared with measurement results of indoor environments. The result is expected to utilize for the MIMO channel modeling in the higher frequency band.

10:00 ***Indoor Channel Characteristics in Atrium Entrance Hall Environment at Millimeter-wave Band***

Minseok Kim, Tatsuki Iwata and Kento Umeki (Niigata University, Japan); Jun-ichi Takada (Tokyo Institute of Technology, Japan); Shigenobu Sasaki (Niigata University, Japan)

This paper presents indoor channel characteristics in atrium entrance hall environment at millimeter-wave band. In this measurement campaign, the base stations (BS) were mounted at a height of approximately 2.8 m on the walls and the user equipment (UE) was located at multiple positions on the floor.

10:20 Coffee Break

10:50 ***A Model for the Reflection of Terahertz Signals From Printed Circuit Boards***

Alexander Fricke and Thomas Kürner (Technische Universität Braunschweig, Germany); Mounir Achir (Canon Research Centre France, France); Philippe Le Bars (Canon CRF, France)

Based on Vector Network Analyzer (VNA) measurements, a model for the specular reflection behavior of printed circuit boards (PCB) in the Terahertz range has been derived. It has been calibrated to suit the behavior of the measurements using a simulated annealing algorithm. The model has been tailored for the integration to ray-tracing based propagation modeling.

11:10 ***Comparison of Path Loss Models for Indoor 30 GHz, 140 GHz, and 300 GHz Channels***

Chia-Lin Cheng and Seunghwan Kim (Georgia Tech, USA); Alenka Zajic (Georgia Institute of Technology, USA)

This paper compares performance of the single-frequency floating-intercept model, the single-frequency close-in model, the multi-frequency alpha-beta-gamma model, and the multi-frequency close-in frequency-dependent model at 30 GHz, 140 GHz, and 300 GHz. For comparison purposes, extensive propagation measurements at 30

GHz (26.5--40 GHz), D-band (110--170 GHz), and 300 GHz (300--316 GHz) are conducted in the indoor line-of-sight (LoS) environments. The results show that if no measurement error is present in the channel impulse response, all four models have very similar performance and the model with the smallest number of parameters would be the optimal choice. On the other hand, the results show that in the presence of measurement errors or lack of detailed antenna gain characterization, models without physical anchor outperform models with physical anchor and correctly predict the reason for path loss mismatch between model and theoretical values.

11:30 ***Investigations on Fading Scaling with Bandwidth and Directivity at 60 GHz***

Diego Dupleich (Ilmenau University of Technology, Germany); Naveed Iqbal (Huawei Technologies, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Robert Müller and Sergii Skoblikov (TU Ilmenau, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

In the present paper we analyse small-scale fading of reflections at 60 GHz using different antennas and bandwidths. The aim is to investigate the deterministic property of the channel in view of modelling and deployment of systems with larger bandwidths and higher directivity. We have investigated the scattering effect of a reflection on a wall emulating a beam-former in a NLOS condition. The results show that the distribution of the amplitudes fit better with a Rician than a Rayleigh distribution. Furthermore, we show that an increasing bandwidth and directivity increases the K-factor, supporting the idea of deterministic paths apart from the LOS.

11:50 ***Multi-frequency Power Angular Spectrum Comparison for an Indoor Environment***

Usman Tahir Virk, Sinh Nguyen and Katsuyuki Haneda (Aalto University, Finland)

This paper presents the comparison of power angular spectra at frequencies below and above 6 GHz, i.e., 2, 15, 28, 60 GHz. With the increased focus on millimeter wave frequencies for ultra-high data rates, a detailed understanding of channel frequency dependence has become crucial. The analysis in this paper is based on multi-frequency radio channel measurements in an indoor coffee room environment for both line-of-sight (LOS) and non-LOS scenarios. For multipath extraction, two different methodologies are used at below and above 6 GHz frequency bands, respectively. The results indicate that LOS channels demonstrate a similar spatial spread at all the frequencies considered, and hence can be spatially modeled in a similar fashion. The NLOS channels exhibit larger spatial spread overall. The paths at above 6 GHz channels appear to be spatially more consistent compared to those that are below 6 GHz, where penetrated and the diffracted paths also exist.

12:10 ***Path Loss Model in Typical Outdoor Environments in the 50-73 GHz Band***

Sana Salous, Xavier Raimundo and Adnan Cheema (Durham University, United Kingdom)

Results of path loss in typical outdoor environments in two frequency bands identified in WRC15 for future 5G radio systems are presented. These include angular path loss as estimated from the strongest component, the main beam, the back beam and from the synthesized omni-directional beam.

TOP

CS29 New Antenna Systems Involving Application of Metamaterials and Metasurfaces (IET)

Future Applications / Convened Session / Antennas

Oral Sessions: Room 351

Chairs: Rob Lewis (BAE Systems Applied Intelligence Laboratories, United Kingdom), Hisamatsu Nakano (Hosei University, Japan)

08:40 ***Characterization of the Efficiency of Metasurface Antennas***

Gabriele Minatti and Enrica Martini (University of Siena, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Stefano Maci (University of Siena, Italy)

Efficiency of modulated metasurface (MTS) antennas is investigated from a theoretical point of view. The MTS antennas we consider are formed by a dense texture of capacitive elements printed on a dielectric slab, backed by a ground plane and fed by a single point source. This is a common configuration for MTS antennas working at the microwave frequencies. We provide compact expressions for the efficiency of MTS antennas and useful indications for their design.

09:00 ***A Tunable Polarization Rotator Based on Metasurfaces***

Zhanni Wu (University of Michigan, Ann Arbor); Younes Ra'di (University of Texas at Austin, USA); Anthony Grbic (University of Michigan, Ann Arbor, USA)

An electronically tunable polarization rotator based on tensor metasurfaces is reported. For a linearly polarized incident wave, the polarization tilt angle can be arbitrarily controlled through a simple biasing mechanism. The proposed metasurface design allows global phase and polarization control simultaneously.

09:20 ***Frequency Selective Surface Loaded Antenna for Direct Antenna Modulation***

Stephen Henthorn, Kenneth Lee Ford and Timothy O'Farrell (University of Sheffield, United Kingdom)

A reconfigurable antenna loaded with Frequency Selective Surfaces (FSS) to achieve direct antenna phase modulation is presented and simulated. Placing FSS with integrated varactor diodes into a monopole-fed cavity allows control of the transmitted phase of a carrier signal with a bias voltage. As such, Direct Antenna Modulation (DAM) can be achieved, producing a phase modulator that can be included in a low complexity transmitter. Simulation shows such an antenna can achieve QPSK modulation with between 3.5dB and 4.5dB magnitude variation between constellation points with acceptable phase stability with radiation angle in the antenna 3dB beamwidth.

09:40 ***Emulating Arbitrary Antenna Arrays with Low-Profile Probe-Fed Cavity-Excited Omega-Bianisotropic Metasurface Antennas***

Ariel Epstein (Technion - Israel Institute of Technology, Israel); George V. Eleftheriades (University of Toronto, Canada)

We present a methodology to design cavity-excited omega-bianisotropic metasurface (O-BMS) antennas capable of producing arbitrary radiation patterns, prescribed by antenna array theory. The method relies on previous work, in which we proved that utilizing the three O-BMS degrees of freedom, namely, electric and magnetic polarizabilities, and magnetoelectric coupling, any field transformation that obeys local power conservation can be implemented via passive lossless components. When the O-BMS acts as the top cover of a metallic cavity excited by a point source, this property allows optimization of the metasurface modal reflection coefficients to establish any desirable power profile on the aperture. Matching in this way the excitation profile to the target power profile corresponding to the desirable aperture fields allows emulation of arbitrary discrete antenna array radiation patterns. The resultant low-profile probed-fed cavity-excited O-BMS antennas offer a new means for meticulous pattern control, without requiring complex, expensive, and often lossy, feed networks.

10:00 ***Overcoming Traditional Electrically Small Antenna Tradeoffs with Meta-Structures***

Richard W. Ziolkowski (University of Arizona, USA); Ming-Chun Tang (College of Communication Engineering, Chongqing University, Chongqing, P.R. China)

Metamaterial-inspired near-field resonant parasitic (NFRP) electrically small antennas (ESAs) have been designed and experimentally validated to have not only high radiation efficiencies, but also multi-functionality, large bandwidths, high directivities and reconfigurability. These expanded capabilities have been attained by introducing more complex meta-structures, i.e., multiple NFRP elements loaded with fixed and tunable lumped elements, as well as active circuits. Different classes of passive and active NFRP ESAs that have successfully produced these effects will be reviewed, and several recently reported ESA systems will be introduced and discussed.

10:20 Coffee Break

10:50 ***Metaline-based Antennas***

Hisamatsu Nakano (Hosei University, Japan)

This paper presents recent developments in metaline-based antennas. Four metalines are presented and application of these metalines to low-profile antennas is discussed: (A) zeroth-order metaline antenna, (B) double metaline antennas, (C) metaloop antennas, (D) metaspiral antennas, and (E) metahelical antennas. Wideband broadside radiation from double metaline antennas and dual-band counter circularly-polarized radiation from the metaloop, metaspiral and metahelical antennas are revealed.

11:10 ***Tailoring of Electromagnetic Waves by Metasurfaces***

Luigi La Spada (Queen Mary University of London, United Kingdom); Yang Hao (Queen Mary University, United Kingdom)

In the last few years, non-homogeneous meta-surfaces captured huge interest in tailoring electromagnetic waves, ranging from microwave to optical frequencies. Several technologies have been proposed, but a general design approach is still missing: the aim of this work is to present a modeling tool for the control of electromagnetic waves propagations. This approach enables to link the meta-surfaces electromagnetic properties with their geometrical and physical characteristics. To validate the proposed approach, two different applications will be reported: a flat Luneburg Lens and a sharp corner guiding structure. Results show good performance in terms of wide bandwidth and source independence.

11:30 ***Design of Microwave Components in Groove Gap Waveguide Technology Implemented by Holey EBG***

Mahsa Ebrahimpouri and Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden); Eva Rajo-Iglesias (University Carlos III of Madrid, Spain)

In this paper, the feasibility of the implementation of microwave components in groove gap waveguide technology by glide-symmetry holey EBG is discussed. Using this technology, microwave components and antennas which were previously designed for hollow metallic waveguides can be manufactured in a cost-effective way at high frequencies. To show the viability of the proposed solution a phase shifter and a mode converter are designed as examples of typical components for antenna systems.

11:50 ***Mode Matching Analysis of Two Dimensional Glide-Symmetric Corrugated Metasurfaces***

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

The mode matching method for analysing two dimensional doubled corrugated metasurfaces, including glide-symmetric corrugated metasurfaces, embedded in a thin parallel plate waveguide is presented. This method is accurate, fast, and without any limitations on the parameters.

12:10 ***Slotted SIW Leaky-Wave Antenna with Improved Backward Scanning Bandwidth and Consistent Gain***

N Nasimuddin (Institute for Infocomm Research, Singapore); Zhi Ning Chen (National University of Singapore, Singapore); Xianming Qing (Institute for Infocomm Research, Singapore)

A dumbbell-shaped slotted leaky-wave antenna based on composite right/left-handed metamaterial structure is proposed to improve the backward scanning bandwidth and achieve consistent gain. The antenna consists of substrate integrated waveguide (SIW) unit cells array, which is configured by a dumbbell-shaped slot, cut on the upper layer of the SIW, and an embedded patch underneath the dumbbell-shaped slot. The antenna improves the backward scanning bandwidth compared with the planar-slotted SIW leaky-wave antenna. A measured beam scanning range of -66° to 78° with consistent gain of > 10 dBi is achieved across a frequency range from 7.5 GHz to 13.0 GHz

Tuesday, March 21, 08:40 - 10:20

R_A01 Mm-Wave Radar Antennas

Radars / Regular Session / Antennas
Oral Sessions: Room 352A
Chairs: Erio Gandini (Delft University of Technology, The Netherlands), Bernard Jecko (XLIM, France)

08:40 ***A Dielectric Lens Antenna Fed by a Flexible Dielectric Waveguide At 160GHz***
Martin Geiger and Martin Hitzler (University of Ulm, Germany); Johannes Iberle (Ulm University of Applied Sciences, Germany); Christian Waldschmidt (University of Ulm, Germany)
Flexible antennas in radar applications enable the user to go around obstacles or detect targets at hidden places. In this paper, two elliptical lenses of different size made of high density polyethylene and stacked on a flexible dielectric waveguide are designed and measured from 140 GHz to 180 GHz. The feeding dielectric waveguide and the mode transition from metallic waveguide to dielectric waveguide was investigated with full wave simulations. The elliptical lenses were designed with a geometrical optics approach. The realized antennas have a gain larger than 24 dBi and 27 dBi and a maximum side lobe level below −15.8 dB.

09:00 ***Gain Enhancement of a Slot Antenna Using Multiple Metasurfaces***
Bilal El Jaafari (Institut d'Electronique et de Télécommunications de Rennes & Institut National des Sciences Appliquées de Rennes, France); Jean-marie Floch (IETR-INSA Rennes, France)
We present in this paper a design of a high gain antenna for radar-based non-contact measurement systems in the k-band frequency. The proposed antenna consists of a slot on a multi-grooved metal structure (flange) and a frequency selective surface (FSS) acting as a flat lens. Often, grooved (or corrugated) surfaces and frequency selective surfaces are used to enhance antenna gain features. The combination of these two techniques could provide more gain with a small size antenna. In this sense, dimensions of both grooves and FSS are optimized to reach the maximum gain without increasing the size of the antenna. All simulations and optimizations are carried out using electromagnetic full-wave tools. Next, a prototype of the proposed antenna is manufactured and characterized. More than 15 dB of gain is obtained over the whole bandwidth with a peak gain of about 17.5 dB is measured around the frequency 24.5 GHz.

09:20 ***Modeling the Response of Dielectric Slabs on Ground Planes Using CW Focused Millimeter Waves***
Mahdiar Sadeghi, Elizabeth Wig, Ann Morgenthaler and Carey Rappaport (Northeastern University, USA)
We present a novel non-iterative model-based on ray analysis to characterize non-metallic, weak dielectric objects (like threat objects) on the surface of a highly conducting background (like the human body) using a focused continuous millimeter-wave sensor. For a simple constant thickness dielectric slab on a ground plane, there are five primary scattering phenomena that must be considered.

09:40 ***Design of Circular Dual and Quad Ridge Horn Antennas for Millimeter Wave Applications***
Nathan Jastram and Conrad Andrews (University of Colorado Boulder, USA); Dejan Filipovic (University of Colorado at Boulder, USA)
The design of circular dual and quad ridged horn antennas covering the 18 to 45 GHz band is discussed. An exponential taper and blending fillet for the ridge profile are presented to minimize 3 dB beamwidth variation while maintaining high boresight gain for both dual and quad ridge horns. Boresight gain for a quad ridge design is greater than 15 dBi, while boresight gain greater than 17.9 dBi is shown for a dual ridge circular horn design. Both horns have axial 3 dB beamwidth variation less than 5 degrees over the entire frequency band.

10:00 ***Design and Experimental Validation of a Wide Field of View Dual-Lens Antenna at Sub-Millimeter Wave Frequencies***
Erio Gandini (Delft University of Technology, The Netherlands); Aleksi Tamminen and Arttu Luukanen (Asqella Oy, Finland); Nuria LLombart (Delft University of Technology, The Netherlands)
A wide field of view dual-lens system is presented in this contribution. The antenna is designed has to work from 250 to 500 GHz. An outline of the design considerations is discussed. The lens system is designed for near-field focusing, at a range of 2.1 m and can be refocused by displacing one lens in from 1.8 to 2.3 m. The simulated results show that over the required field of view of ±25.4° (±1 m at the nominal range) the gain variation is approximately 3 dB. Moreover, the half power beamwidth at the edge of the field of view increases by only a factor 1.4 compared to the broadside pattern. This makes the design suited for imaging systems since the image resolution is practically constant over the field of view. The dual lens system was fabricated and the measurements confirm the predicted performance.

CS45 Smart Beamforming in Far-Field Wireless Power Transmission

Localization & Connected Objects / Convened Session / Antennas
Oral Sessions: Room 352B
Chairs: Diego Masotti (University of Bologna, Italy), Pedro Tavares Pinho (ISEL & ISEL - Instituto Superior de Engenharia de Lisboa, Portugal)

08:40 ***3D Printed Lens Antenna for Wireless Power Transfer At Ku-Band***
Ricardo Gonçalves (Instituto de Telecomunicações - Aveiro & Evoleo Technologies, Portugal); Pedro Tavares Pinho (ISEL & ISEL - Instituto Superior de Engenharia de Lisboa, Portugal); Nuno Borges Carvalho (University of Aveiro/IT Aveiro, Portugal)
In this paper we present the design of an antenna, operating in the Ku-band, conceived for wireless power transfer systems. It comprises an hemispherical dielectric lens, fabricated using 3D printing technology, fed by a microstrip patch antenna array. The conjugation of the dielectric lens with the microstrip patch array allows the development of a compact high gain antenna. The antenna presents a matched bandwidth between 12.7 and 13.15 GHz and a maximum gain of 18.1 dBi at each element.

09:00 ***Design Methodology for the Multi-Beam Phased Array of Antennas with Relatively Arbitrary Coverage Sector***
Hsi-Tseng Chou (National Taiwan University, Taiwan)
This paper presents the design methodology of multi-beam phased array of antennas that may provide high gain and narrow beam radiation patterns within a desired coverage range. The advantages of high energy efficiency in the coverage area provide the flexibility of applications in various area such as wireless power transmission and mobile communications. The relatively flexible mechanism to determine the number of beams, beamwidth and beam directions makes the proposed method very useful in the practical implementation of multi-beam antennas. The methodology is summarized with an example to demonstrate the feasibility.

09:20 ***Study of Flat Beam in Near-field for Beam-Type Wireless Power Transfer via Microwaves***
Naoki Shinohara and Naoki Kamiyoshikawa (Kyoto University, Japan)
This study proposes a simple method for creating flat beam patterns in a near-field. In radio-wave transmission, the near-field beam efficiency of the beam-type wireless power transfer (WPT) system theoretically reaches 100%, but the beam pattern is not flat in the near field. In real beam-type WPT systems, the total beam efficiency (DC-RF-transmission, beam efficiency, and RF-DC conversion) can be improved by increasing the RF-DC efficiency of the rectenna. However, the rectenna requires a flat beam pattern in the near-field. In the present study, we create a flat beam pattern in the near field of a multicopter assisted wireless batteryless sensing system.

09:40 ***Time-based RF Showers for Energy-Aware Power Transmission***
Diego Masotti (University of Bologna, Italy); Alessandra Costanzo (DEI, University of Bologna, Italy)
This paper proposes a review of the use of time-based arrays as RF energy providers in those wireless applications where an energy-aware transmission is of key importance. The higher simplicity and versatility of time-modulated arrays (TMAs) with respect to other modern radiating systems is deeply discussed: in particular, the multi-harmonic radiation capability of TMA is efficiently deployed in the smart wireless power transfer procedure. This two-step procedure is demonstrated through a 2.45 GHz 8-monopole planar array, by resorting to a rigorous co-simulation approach: it combines the Harmonic Balance technique, for the accurate description of the nonlinear switches, with the full-wave analysis of the array and its feeding network.

10:00 ***Transient Directed WPT***
Hubregt J. Visser (imec The Netherlands, The Netherlands)
The use of an array antenna, transmitting pulsed signals and applying time-delays between the elements to create an area of high power density in front of the array at a prescribed position at a chosen moment in time is discussed. Using realistic bandwidths and pulse repetition frequencies leads to the creation of undesirable hot spots. Replacing the array elements with small phased array antennas proves to cure this phenomenon.

Tuesday, March 21, 08:40 - 12:30

CS04 Advanced Statistical Methods and Tools in Applied Electromagnetism

TOP

Methods & Tools / Convened Session / Propagation
Oral Sessions: Room 353
Chairs: Philippe De Doncker (ULB, Belgium), Raj Mittra (Penn State University, USA)

08:40 ***Surrogate Models for Uncertainty Quantification: An Overview***
Bruno Sudret and Stefano Marelli (ETH Zurich, Switzerland); Joe Wiart (Telecom ParisTech, France)
Uncertainty quantification has become a hot topic in computational sciences in the last decade. Indeed computer models (a.k.a simulators) are becoming more and more complex and demanding, yet the knowledge of the input parameters to feed into the model is usually limited. Based on the available data and possibly expert knowledge, parameters are represented by random variables. Of crucial interest is the propagation of the uncertainties through the simulator so as to estimate statistics of the quantities of interest. Monte Carlo simulation, a popular technique

based on random number simulation, is unaffordable in practice when each simulator run takes minutes to hours. In this contribution we shortly review recent techniques to bypass Monte Carlo simulation, namely surrogate models. The basics of polynomial chaos expansions and low-rank tensor approximations are given together with hints on how to derive the statistics of interest, namely moments, sensitivity indices or probabilities of failure.

09:00 ***Statistical Analysis of Electromagnetic Structures and Antennas Using the Polynomial Chaos Expansion***

Hulusi Acikgoz (KTO Karatay University, Turkey); Raj Mittra (Penn State University, USA)

Electromagnetic (EM) structures such as antennas, resonators, are widely used in EM communication systems. It is not uncommon to find that the performance characteristics of these structures are not as expected because of the uncertainties introduced during the manufacturing process. These uncertainties may arise, for instance, from variations of the dimensions of the device or its material properties, e.g., permittivity and permeability. A statistical tool based on the use of the Polynomial Chaos Expansion (PCE) technique is proposed in this work. The results of investigation of two EM structures, namely an E-shaped patch antenna and a split-ring resonator (SRR), are presented as examples. The results confirm that the variability of the design parameters must be taken into account while designing such structures. A sensitivity analysis is also performed in order to determine the most influential parameters that affect the performance of the studied structures.

09:20 ***Sensitivity Analysis of the Time Transient Currents Induced Along Thin Wires Buried in Lossy and Uncertain Environments***

Sebastien Lalléchère (Université Clermont Auvergne, France); Silvestar Sesnic (University of Split, Croatia); Pierre Bonnet (Blaise Pascal University, France); Khalil El Khamlichi Drissi (Universite Blaise Pascal & LASMEA Laboratory, France); Françoise Paladian (Blaise Pascal University, France); Dragan Poljak (University of Split, Croatia)

This contribution aims to assess the sensitivity of the time domain response of a straight thin electrode buried in a lossy half-space. The issue is of crucial importance in many fields including electrical engineering (e.g. ground penetrating radar purposes, lightning protection for electrical settlements). Indeed, such systems are subject to more and more complex radiating coupling, mostly due to the variability of input parameters. An alternative approach to classical Sobol' indices is proposed here, jointly with an advanced analytical resolution of Pocklington integro-differential equation.

09:40 ***Statistical Analysis and Surrogate Modeling of Indoor Exposure Induced from a WLAN Source***

Yenny C Pinto (Institut Mines Telecom, Telecom ParisTech, France); Joe Wiart (Telecom ParisTech, France)

This paper is focused on the statistical analysis of the human indoor exposure induced by a WLAN source (often named "box") located close to the walls of a room of 3*4 m2. The exposure is firstly assessed by using a hybridize method combining the spherical wave description and the FDTD numerical method. A scenario, where the anatomical model is located in unknowing room position and the source is near to the wall but in an unknowing position is analyzed. Due to the variability of this scenario, the entire possible configurations cannot be calculated with the FDTD. A statistical method based on Polynomial Chaos is therefore discussed and used to build a surrogate model allowing to assess the exposure distribution.

10:00 ***Statistical Evaluation of the Tissue Specified Specific Absorption Rate Using Principal Component Regression***

Tongning Wu and Congsheng Li (CATR, P.R. China)

This study focused on the evaluation of the tissue specified specific absorption rate (TSSAR) for a wide frequency band. Principal component regression was used to fit the model using six anatomical and dielectric factors. The results demonstrated that the method could effectively reduce the dimension of the variables and the fitted model for one frequency was applicable to other frequencies.

10:20 Coffee Break

10:50 ***Advanced Statistical Methods Applied to a Simplifed Assessment of Population Exposure Induced by a LTE Network***

Yuanyuan Huang (Télécom Bretagne, France); Nadège Varsier and Zwi Altman (Orange Labs, France); Thomas Courtat (Télécom ParisTech, France); Philippe Martins (Telecom Paristech, France); Laurent Decreusefond (Telecom ParisTech & CNRS LTCI, France); Christian Person (Lab-STICC/MOM UMR CNRS, France); Joe Wiart (Telecom ParisTech, France)

This study presents a simplified methodology based on advanced statistical tools to evaluate the day-to-day global electromagnetic (EM) field exposure of a population taking into account the variability and uncertainties linked to propagation environment, information and communication technology usage, as well as EM fields from personal wireless devices and base stations. A sensitivity analysis was carried out in order to assess the influence of these parameters on EM field exposure. Results have highlighted the importance of received power density from base stations to the issue of global exposure induced by a macro LTE network for an entire population in an urban area.

11:10 ***Propagation of Uncertainty in the MUSIC Algorithm Using Polynomial Chaos Expansions***

Thomas Van der Vorst (Université Libre de Bruxelles, Belgium); Mathieu Van Eeckhaute (Université libre de Bruxelles (ULB), Belgium); Aziz Benlarbi-Delaï (Sorbonne Universités, UPMC Paris 06, France); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); François Horlin (Université Libre de Bruxelles, Belgium); Philippe De Doncker (ULB, Belgium)

Polynomial chaos expansions are used to analyze the propagation of uncertainties on array parameters in Angle-of-Arrival estimation performed by the MUSIC algorithm.

11:30 ***Generalized Polynomial Chaos Paradigms to Model Uncertainty in Wireless Links***

Marco Rossi, Dries Vande Ginste and Hendrik Rogier (Ghent University, Belgium)

A stochastic framework is proposed to evaluate the effect of random effects on the overall performance of wireless links. A generalized polynomial chaos expansion is leveraged to relate the uncertainties in antenna geometry, orientation and position to the figures of merit characterizing the link. The stochastic testing procedure is proposed as a more efficient alternative to stochastic collocation, for a large number of random variables. The non-intrusive statistical framework is applied to evaluate the uncertainty on the efficiency of a wireless power transfer system.

11:50 ***Adding Diffuse Scattering Correlation to Effective Roughness Models in Ray Tracing***

Yang Miao (Catholique Universite de Louvain, Belgium); Quentin Gueuning (Université Catholique de Louvain, Belgium); Mingming Gan (AIT Austrian Institute of Technology GmbH, Austria); Claude Oestges (Université Catholique de Louvain, Belgium)

This paper proposes to add diffuse scattering correlation to Effective Roughness (ER) models used in ray tracing. Diffuse scattering correlation is modeled by phase evolution models including a deterministic part and a correlated (random) part. The deterministic part is dependent on the distance variations between the moving terminal and each ER tile, and the correlated part is related to the angular variations. The predicted narrowband radio channels by ray tracing with proposed diffuse scattering correlation are compared with those obtained by applying a reference physical optics approach, in terms of the Doppler properties over spatial frequency.

12:10 ***Preliminary Statistical Analysis of Four Site Diversity Experiment at Ka-band***

Arsim Kelmendi and Andrej Vilhar (Jozef Stefan Institute, Slovenia)

This paper describes the ongoing site-diversity experiment, consisting of three beacon receiver stations in Slovenia and one station in Austria. All the four stations are identical in configuration and are measuring the 20.2 GHz beacon signal, transmitted from the ASTRA 3B geostationary satellite. The stations were gradually deployed in the years 2014 and 2015. The measured attenuation time series and joint attenuation time series are obtained and statistically analysed. The results are presented in two parts: a) for one full year of collected data from the three Slovenian stations, and b) for seven months of recently collected measurement data in the four-site constellation, including the Austrian station. The results confirm the benefits of site diversity system in terms of significant attenuation reduction. They are compared also to the existing ITU-R and the recently proposed Gaussian copula prediction models and the agreement is satisfactory.

Tuesday, March 21, 08:40 - 10:20

F_A04 Submillimeter-wave & Terahertz antenna

TOP

Future Applications / Regular Session / Antennas

Oral Sessions: Room 362/363

Chairs: Luis-Enrique Garcia-Muñoz (University Carlos III of Madrid, Spain), Nuria LLombart (Delft University of Technology, The Netherlands)

08:40 ***Analytical Study of Free-Space Coupling of THz Radiation for a New Radioastronomy Receiver Concept***

Gabriel Santamaria Botello and Kerlos Atia Abdalmalak (Universidad Carlos III de Madrid, Spain); Maria-Theresa Schlecht (Universitaet Erlangen-Nuremberg, Germany); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Florian Sedlmeir, Harald Schwefel and Stefan Malzer (Max Planck Institute for the Science of Light, Germany); Heiko Weber (Universitaet Erlangen-Nuremberg, Germany); Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain); Darragh McCarthy and John Anthony Murphy (National University of Ireland Maynooth, Ireland); Gottfried H. Döhler (Max Planck Institute for the Science of Light, Germany); Luis-Enrique Garcia-Muñoz (University Carlos III of Madrid, Spain)

In this paper, a scheme for coupling free-space THz radiation into a nonlinear whispering-gallery mode (WGM) resonator is presented. The purpose is to detect the weak THz radiation from the cosmic microwave background (CMB) by up-converting the signal into the optical domain via to the nonlinearity of the medium. Such high-sensitivity receiver has theoretically shown capabilities towards photon counting at room temperature, however, it is critical to efficiently couple the THz radiation into the resonator. Therefore, by using the Schelkunoff-Waterman method (the so called T-matrix method) we perform an analytical evaluation of two different free-space coupling techniques: a free-space Gaussian beam, and a Gaussian beam incident in a silicon lens under total internal reflection. By comparing the excited modes in the resonator, the optimal parameters for each case are given.

09:00 ***Recent Work on (sub-)mm-wave Ultra WideBand Corrugated Horns for Radio Astronomy***

Alvaro Gonzalez and Keiko Kaneko (National Astronomical Observatory of Japan, Japan); Shin'Ichiro Asayama (National Astronomical Observatory of Japan, Chile)

Corrugated horns are widely used in many applications, including radio astronomy, because of their high performance over large bandwidths. However, the always increasing demand for wider frequency coverage cannot be met by traditional conical corrugated horns with typical fabrication constraints at (sub-)mm wavelengths. The usual way to overcome this limitation is to use profiled corrugated horns, such as the 275-500 GHz horn presented in this paper. As an alternative, we propose and demonstrate that conical corrugated horns can achieve ultra-wideband (UWB) performance by changing the depth of corrugations along the horn. A design for the 67-116 GHz

band is presented. Fabrication of these two designs is on-going and measurements will be presented at the conference.

09:20 ***Validation by Power Measurements of a Norton Equivalent Circuit Model for Photoconductive Antennas***

Alessandro Garufo and Giorgio Carluccio (Delft University of Technology, The Netherlands); Joshua R Freeman (University of Leeds, United Kingdom); David Bacon (University of Leeds, The Netherlands); Nuria LLombart (Delft University of Technology, The Netherlands); E. Linfield (School of Electronic and Electrical Engineering, University of Leeds, United Kingdom); Alexander Davies (University of Leeds, United Kingdom); Andrea Neto (Delft University of Technology, The Netherlands)

A validation of a recently proposed equivalent circuit model for describing the radiation of photoconductive antennas is shown in this work. The validation is obtained by comparing the power estimated by the model against radiated power measurements of a manufactured prototype. The model describes the feeding mechanism of an antenna provided via a photoconductor gap, when it is optically pumped by a laser, taking into account for the electrical proprieties of the material, for the geometrical sizes of the gap, and for the laser power excitation. Two different measurement setup have been used, in order to verify the accuracy of the measurements. In order to compare the estimation of the power predicted by the model and the measurements, an evaluation of the efficiencies involved in the THz measurement quasi-optical system has been performed for both the setups. A good agreement is achieved between measurements and power estimated with the model.

09:40 ***A 45º-Inclined Linearly Polarized Probe for Terahertz Mueller Imaging***

Xuexuan Ruan, Kung Bo Ng and Chun Kit Wong (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)

This paper proposes a novel terahertz (THz) probe based on a pyramidal-shaped TE10 mode rectangular open ended waveguide (OEWG) integrated with a 45º-inclined linearly polarized (LP) element. The radiating element, deposited on top of the OEWG, is realized using standard printed-circuit and plated-through-hole technologies. The pyramidal fixture, situated beneath the substrate, is made of brass with gold plated. Experimental results show that the proposed probe can present an impedance bandwidth (VSWR ≤ 2) better than 15.2% from 279 to more than 325 GHz. Within the impedance bandwidth, the gain varies from 5.3 to 10.2 dBi and all radiation patterns are symmetric with low cross-polarization and back radiation levels. The proposed probe is a good candidate for Mueller imaging in THz range.

10:00 ***A Reconfigurable Multilayered THz Leaky-Wave Antenna Employing Liquid Crystals***

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

In this work, the tunable properties of nematic liquid crystals are exploited in order to design a Fabry-Perot cavity (FPC) leaky-wave antenna (LWA) with beam-steering capability at fixed frequency in the THz range. The considered design is a grounded dielectric slab covered with a multistack of alternating layers of low- and high-permittivity dielectric materials, consisting of nematic liquid crystals and alumina thin films, respectively. The former allows for achieving the beam-steering capability at a fixed frequency. Full-wave simulations confirmed the pattern reconfigurability of the device, thus opening very interesting possibilities for the realization of reconfigurable THz antennas.

TOP

IWS_01: How to design a matching circuit that matches with the measurements?

WG Meetings & Workshops: Room 313/314

Chair: Jaakko Juntunen (Optenni Ltd., Finland)

Tuesday, March 21, 10:50 - 12:30

TOP

W_A02 Arrays Antenna for Wireless Networks

Wireless Networks / Regular Session / Antennas

Oral Sessions: Room 341

Chairs: Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy), Patrice Pajusco (TELECOM Bretagne, France)

10:50 ***Analysis of Hybrid-Passive-Active Phased Array Configurations Based on an SNR Approximation***

Matthias Nickel, Onur H. Karabey, Matthias Maasch, Roland Reese, Matthias Jost and Christian Damm (Technische Universität Darmstadt, Germany); Rolf Jakoby (Institute for Microwave Engineering and Photonics, Technische Universität Darmstadt, Germany); Holger Maune

(Technische Universität Darmstadt, Germany)

In this work, the impact of different system configurations on the SNR performance of hybrid-passive-active phased arrays is studied. The separation of the functional core components of active arrays into active and passive parts provides the possibility to reduce power consumption, size and cost, which is of interest especially in mobile applications. Power consuming and expensive active components, such as LNAs, can be shared by multiple antenna elements, whereas passive components, e.g. passive phase shifters, are assigned to each antenna element for beam steering. To estimate the performance of such systems, a noise model is derived for a planar M times N, corporate fed array in tile construction. With this model, it is possible to determine an optimum array configuration in terms of array size and LNA distribution for a given SNR design goal and a given set of limiting factors.

11:10 ***Feasibility of Dual-polarized Antenna Arrays for GNSS Receivers at Low Elevations***

Maysam Ibraheam (Ilmenau University of Technology, Germany); Bjoern Bieske (Institute for Mechatronics and Microelectronic Systems GmbH, Germany); Kurt Gerd Blau (Technische Universität Ilmenau, Germany); Eric Schäfer (Ilmenau University of Technology, Germany); Andre Jäger (IMMS GmbH, Germany); Safwat Irteza Butt (Robert Bosch GmbH, Germany); Ralf Stephan (Technische Universität Ilmenau, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

A dual-band dual-polarized compact antenna array is designed for intended use in robust global navigation satellite receivers. The four-element antenna array is connected to an eigenmode-based decoupling and matching network to compensate for the radiation efficiency degraded by mutual coupling. The resulting eigenmodes of the array are then fed to an RF-IF front-end for down-converting, filtering, and power amplification. Finally, the signals are carried to a digital receiver for decoding and tracking. Field measurements proved the usability of certain left-hand circular polarized modes for receiving the navigation signals, particularly at low elevations. This possibility enhances the receiver robustness against polarization distortion caused by multipath, and thus improves the tracking accuracy. Measurements help also to decide which left-hand modes should be selected for a practical dual-polarized receiver if the number of channels available for array signal processing is limited.

11:30 ***Synthesis of Clustered Linear Arrays Through a Total Variation Compressive Sensing Approach***

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

In this work the problem of synthesizing the excitations of a linear array, clustered into contiguous sub- arrays of irregular length, is addressed. By suitably exploiting the behavior of clustered array aperture distributions (i.e., step-wise discrete functions), the problem has been formulated as the minimization of the total variation (TV) of the excitations, satisfying a matching condition on a predefined reference pattern. In virtue of the sparse nature of the unknowns, the minimization problem has been solved by means of an efficient total variation compressive sensing (TV- CS) optimization approach. A simple example validating the proposed technique is finally reported.

11:50 ***Massive Antenna Array for Space Time Channel Sounding***

Patrice Pajusco (Telecom Bretagne); Francois Gallée (Télécom Bretagne, France); Nadine Malhouroux (France Telecom Research & Development, France); Roxana Burghelea (Telecom Bretagne, France)

In this paper, a prototype of a dual-polarized array antenna is presented. This array was designed in the framework of a collaborative project on spatial modulation scheme. It will be used for the project testbed and for space-time channel measurements. This array includes several novelties such as a slant uniform planar structure, scalable design including integrated switching circuitry, along with a reference antenna and a camera. The array has been successfully used with a wideband channel sounder to provide real-time radio photos.

12:10 ***Pattern Recovering of Conformal Antenna Array for Strongly Deformed Surfaces***

Francesco Rigobello (University of Padova, Italy); Giulia Mansutti (Università degli Studi di Padova, Italy); Muhammad Saeed Khan (COMSATS Institute of Information Technology, Pakistan); Antonio-D. Capobianco (University of Padova, Italy)

Pattern recovering of conformal phased array on changing surfaces is receiving an increasing attention in the last years. This paper presents the pattern recovery of a strongly deformed conformal phased-array using the projection method. A 4 × 4 flat array is placed on a doubly curved surface. The phase compensation technique is applied first on rows, and then, considering rows as single antenna elements, on array columns. This technique was proved to be effective in recovering direction and width at half maximum of the pattern main lobe and in suppressing side lobes. Analytically predicted recovered patterns are confirmed through full-wave numerical simulations.

TOP

R_P04 RCS Models

Radars / Regular Session / Propagation

Oral Sessions: Room 352A

Chairs: Christophe Craeye (Université Catholique de Louvain, Belgium), Fernando Las-Heras (Universidad de Oviedo, Spain)

10:50 ***Monostatic RCS of Electrically Large Structures Using Higher-Order MLFMM***

Oscar Borries, Erik Jørgensen and Peter Meincke (TICRA, Denmark)

The monostatic radar cross section (RCS) is an important design parameter for many applications, but accurate

RCS prediction of an electrically large structure continues to be a challenging task. High accuracy demands and a complicated geometry often mean that asymptotic methods are not applicable, while a full-wave method has traditionally required very large computational resources. In the present paper, we avoid the f^6 computational time scaling of the Method of Moments by applying the Multi-Level Fast Multipole Method (MLFMM). A range of modifications to the traditional way of applying MLFMM to monostatic RCS are implemented in order to achieve strong computational performance even on modest hardware.

11:10 ***Modeling of Bistatic Scattering from the Anisotropic Earth Surfaces***

Davide Comite (Sapienza University of Rome, Italy); Franco Fois (Delft University of Technology, The Netherlands); Nazzareno Pierdicca (Uni Roma1, Italy)

Approximate numerical modeling of microwave bistatic scattering (BS) from anisotropic rough surfaces, simulating large baselines radar bistatic system, is analyzed in this contribution. The investigation is performed in the framework of the SAOCOM-CS scientific satellite mission, a small satellite under design by the European Space Agency, to be associated with the Argentinian SAOCOM 1B satellite, aiming at collecting bistatic radar data at L-band. Similar bistatic concepts are being investigated at C-band as well. The main features of the normalized radar cross section (NRCS) of the sea surface in different operating conditions are discussed. This represents the first step to assess the potentiality of bistatic radar observations of natural surfaces with large baseline, and to gather valuable information on the bistatic scattering properties for the design of future spatial missions.

11:30 ***Spectral Polarimetric Features Analysis of Wind Turbine Clutter in Weather Radar***

Jiapeng Yin, Oleg Krasnov and Christine Unal (Delft University of Technology, The Netherlands); Stefano Medagli (TU Delft & Thales, The Netherlands); Herman Russchenberg (Delft University of Technology, The Netherlands)

Wind turbine clutter has gradually become a concern for the radar community for its increasing size and quantity worldwide. Based on the S-band polarimetric Doppler PARSAX radar measurements, this paper demonstrates the micro-Doppler features and spectral-polarimetric characteristic of wind turbine clutter, the probability distribution functions of different spectral-polarimetric variables. Finally, a simple thresholding method to remove wind turbine clutter is put forward, and its effectiveness can be verified by the measured data. This work is expected to contribute to developing effective algorithms for this dynamic clutter suppression for operational weather radar.

11:50 ***Modular Terrain Modeling with Flexible Conductive Materials in a Scaled Measurement Environment***

Björn Neubauer, Robert Geise, Georg Zimmer, Oliver Kerfin and Angela Andree (Technische Universität Braunschweig, Germany); Norbert Ueffing (Piller Germany GmbH & Co. KG, Germany)

Wave propagation over terrain topologies and surface wave propagation relate to several practical applications the simulations of which often become very complex and reach their limits due to the size of objects. Exemplarily, one application is the illumination issue of wind turbines located on different terrains, such as hills in the context of potential bearing errors of the VHF omnidirectional radio range (VOR) due to multipath propagation. Preferably, due to the flexibility of measurements, such investigations are conducted in scaled environments where the object's dimensions are decreased by the same factor the frequencies are increased. This contribution presents the manufacturing process of lightweight, modular pieces with carbon twill fabric on a rigid foam, fastened by epoxy resin using the example of terrain modeling. Corresponding material parameter characterization with radar cross section measurements is carried out. A generic scaled mountain model is constructed and measurements of over-the-hill-propagation are conducted and interpreted

12:10 ***Analytical Formulation for the micro-Doppler Spectrum for Rotating Targets in the Near-Field***

Jean Léger, Thomas Pairon and Christophe Craeye (Université Catholique de Louvain, Belgium)

The analysis of the Doppler signal returned by rotating targets is of great interest in the framework of target recognition and equipment monitoring. An analytical expression of such a signal already exists for the far-field case, based on the Jacobi-Anger expansion. An extension of this analytical expression is proposed for the near-field case. The solution involves a closed-form expression of each harmonic complex coefficient. An error analysis is carried out.

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L_A02 Wireless Power Transmission and Harvesting II

Localization & Connected Objects / Regular Session / Antennas

Oral Sessions: Room 352B

Chairs: Polina Kapitanova (ITMO University, Russia), Carl Pfeiffer (Defense Engineering Corp & Air Force Research Labs, USA)

10:50 ***Long Slot Array for Wireless Power Transmission***

Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Waleed Alomar (KACST, Saudi Arabia); Anthony Grbic (University of Michigan, Ann Arbor, USA)

Retrodirective antennas used for radiative wireless power transfer (WPT) are typically resonant and exhibit strong backscatter, a limited field of view and small bandwidth. These limitations are here overcome by using an array of long slots fed by parallel plate waveguides (PPWs). It is shown that the array can collect the total power impinging from a remote source over a large field of view and bandwidth. The conclusions arrived at for the infinite case are extended to the finite case through full-wave simulations.

11:10 ***Retrodirective Antenna Array for Circularly Polarized Wireless Power Transmission***

Pascual Hilario Re, Symon K. Podilchak, Samuel Rotenberg and George Goussetis (Heriot-Watt University, United Kingdom); Jaesup Lee (Samsung Electronics Co., Ltd, Korea)

In this paper, a retrodirective antenna (RDA) array for wireless power transmission (WPT) is presented. Applications include the charging of mobile device batteries wirelessly. Thanks to the principle of phase conjugation in mixers, retrodirectivity can be achieved in the far-field. More specifically, the reported RDA architecture deals with an active transmitter module to retrodirect a received beacon tone, with increased power, from a mobile unit and with circularly polarized (CP) radiation. Measurements and simulations show a good agreement in terms of the retrodirective tracking capabilities. In addition, a new RDA architecture is also proposed for WPT, using sub-arrays, in order to boost the overall received power at the mobile while also not significantly increasing the costs of the active transmitter module. Other applications for the proposed RDA circuit element include target tracking, low-cost sensor charging, and other WPT systems.

11:30 ***An Efficient RF Energy Harvesting System***

Aline Eid and Joseph Costantine (American University of Beirut, Lebanon); Youssef Tawk (The University of New Mexico & Notre Dame University Louaize, USA); Ali Ramadan (Fahad Bin Sultan University, Saudi Arabia); Mahmoud Abdallah, Rena ElHajj, Rayan Awad and Ingrid Kasbah (American University of Beirut, Lebanon)

This paper proposes a new radio frequency (RF) energy harvesting system that operates over the WiFi 802.11 b/g band at low input power levels. The system presented herein achieves good power conversion efficiencies (PCEs) over a power range that extends from (-20 dBm) to (3 dBm). A directive slot antenna is incorporated to drive the rectification process of the designed rectenna. The rectenna system is measured and tested, along with a power management circuitry, for design validation purposes. A good agreement between simulated and measured results is attained.

11:50 ***On the Design of Frequency Diverse Arrays for Wireless Power Transmission***

A-Min Yao (Nanjing University of Science and Technology, P.R. China); Paolo Rocca (University of Trento, Italy); Wen Wu (Nanjing University of Science & Technology, P.R. China); Andrea Massa (University of Trento, Italy)

This paper proposes a frequency diverse array (FDA) design approach, based on nonlinear frequency offsets and time-modulated weights, for far-field wireless power transmission (WPT). The objective is to optimize the frequency offsets and weights across the array elements to provide maximum end-to-end energy transfer efficiency (ETE). A set of numerical examples is reported and discussed to validate the effectiveness of the proposed WPT-FDA approach.

12:10 ***Colossal Permittivity Resonators for Wireless Power Transfer Systems***

Mingzhao Song, Pavel Belov and Polina Kapitanova (ITMO University, Russia)

We propose a colossal permittivity dielectric resonator for magnetic resonant wireless power transfer system.An experimental investigation is performed and the maximal power transfer efficiency is 90% and the efficiency of 50% is achieved at separation between the resonators d=16 cm (3.8 radii of the resonator). The power transfer efficiency as a function of distance, misalignment and rotation angle is calculated. We also fabricate a prototype with a real load of an LED for demonstration.

TOP

F_A05 Adaptive & Reconfigurable Antennas for Future Applications

Future Applications / Regular Session / Antennas

Oral Sessions: Room 362/363

Chairs: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia), Adam Narbudowicz (Dublin Institute of Technology, Ireland)

10:50 ***A Multifunction Antenna with Direct Modulation and Beam Agility***

Samir Ouedraogo (SONDRA\CentraleSupélec, France); Israel Hinostroza (SONDRA, Supélec, France); Regis Guinvarc'h (SONDRA, Supelec, France); Raphael Gillard (IETR & INSA, France)

An antenna system simultaneously providing a radar function and a secondary communication function with beam agility is proposed. The system is composed of a slotted waveguide (for the communication function) feeding a horn antenna (for the radar function). Direct modulation in four different directions can be obtained for communication provided each radiating slot is equipped with a simple switch.

11:10 ***Beamspace Multiplexing for Wireless Millimeter-Wave Backhaul Link***

Yuan Ding (Queen's University Belfast & The ECIT, United Kingdom); Vincent Fusco and Alexey Shitvov (Queen's University Belfast, United Kingdom)

This paper studies the beamspace multiplexing for free-space wireless millimeter-wave (mm-wave) backhaul applications, which has never been investigated before. A system architecture of a dual-beam mm-wave link is established, and the synthesis approach for the system key parameters that enable the beamspace multiplexing is presented. Extensive simulations are performed and the obtained results show a higher spectrum efficiency in the proposed beamspace multiplexing backhaul link than that could be achieved in the single beam system under the constraint of the same transmitted power.

11:30 ***Realization of a Compact Antenna with Reconfigurable Pattern for Multiple Antenna Systems***

Jerzy Kowalewski and Lepold Keller-Bauer (Karlsruhe Institute of Technology, Germany); Tobias Mahler (Karlsruhe Institute of Technology (KIT), Germany); Jonathan Mayer (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

A pattern reconfigurable antenna for a multiple-input multiple-output (MIMO) antenna system is presented in this paper. For this antenna a feeding structure, consisting of back-to-back balun, that supports realization of different radiation patterns is proposed. Thanks to novel application of this feeding structure any wanted switchable directivity patterns can be realized. Presented antenna generates two switchable patterns, which are optimized for automotive case. As a proof of concept a prototype of this antenna has been fabricated and measured. In this case p-i-n diodes are used as switching elements. The maximal gain achieved is about 6.5dBi. The measurement results correspond well with the simulation results in terms of S-parameter and radiation.

11:50 ***The Pattern Selection Capability of a Printed ESPAR Antenna***

Leonidas Marantis (University of Piraeus, Greece); Konstantinos Maliatsos (University of Piraeus & National Technical University of Athens, Greece); Christos Oikonomopoulos-Zachos (IMST GmbH, Germany); Dimitrios K. Rongas (National Technical University of Athens, Greece); Anastasios Paraskevopoulos (Loughborough University, United Kingdom & University of Piraeus, Greece); Antonis Aspreas and Athanasios G. Kanatas (University of Piraeus, Greece)

The research work presented in this paper involves a proof-of-concept indoor experiment that demonstrates the beamforming capability of an Electronically Switched Parasitic Array Radiator (ESPAR) antenna. A new 3-element ESPAR antenna, formed by one active and two parasitic printed monopoles, is proposed. Two prototypes, which operate at 3.55 GHz, are modeled, fabricated and measured, exhibiting a reconfigurable pattern (three operating modes) and a satisfying directivity increase between the omni-directional and the two directional states. The two ESPARs are embedded in a IEEE 802.11p transceiver, in order to perform a beam selection concept in an indoor environment and evaluate the overall performance in a system level. When the two antennas focus their radiations patterns towards each other, an average of more than 6.5 dB Signal to Noise Ratio (SNR) gain is achieved, compared to the omnidirectional mode.

12:10 ***Concept of a Beam-Steerable Cavity-Fed Antenna with Magnetic-Dipole Coupling Elements***

Nghia Nguyen-Trong (University of Adelaide, Australia); Andrew Piotrowski (Defence Science and Technology Group (DSTG), Australia); Leonard Hall (Defence Science and Technology Organisation, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

A concept of a beam-steerable radiator based on a reconfigurable cavity antenna and coupling elements is proposed in this paper. The coupling elements are designed as magnetic dipoles which are realized using half-mode substrate-integrated cavities. Thus, the antenna exhibits vertical polarization in a planar structure. The main beam can be switched among different directions towards end-fire. Furthermore, by using an array of PIN diodes to reconfigure the aperture size of the launching element, the antenna has potential to change its operating frequency. Simulation results are provided as a preliminary demonstration of the concept.

TOP

WG_02 Small Antennas

WG Meetings & Workshops: Room 313/314

Chair: Pavel Hazdra (Czech Technical University in Prague, Czech Republic)

TOP

IWS_05: ANSYS Workshop: Antenna Placement and Coupling

WG Meetings & WorkShops: Room 315

Chair: Alain Michel (Ansys France, France)

Tuesday, March 21, 13:30 - 15:00

TOP

Poster_01

High Data Rate / Biomedical / Regular Session / Antennas

Room: Poster Sessions: Corridor Neuilly

Chairs: Nader Behdad (University of Wisconsin-Madison, USA), Aziz Benlarbi-Delaï (Sorbonne Universités, UPMC Paris 06, France)

Dispersion Analysis of a Reconfigurable Grounded Slab of Liquid Crystal Loaded by an Inductive Metasurface

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Enrica Martini, Francesco Caminita, Matteo Albani and Stefano Maci (University of Siena, Italy)

The surface wave dispersion of a grounded layer of liquid crystals (LCs) is investigated by taking into account the

inherent electrical reconfigurability of such a material. The dyadic impedance Green's function of the tunable LC grounded slab is calculated and the dispersion curve of the fundamental mode supported by the structure is presented, showing that the orientation of the optical axis of the LCs modifies the surface wave dispersion diagram and can be applied for surface wave propagation control. Furthermore, it is demonstrated that the presence of an inductive metasurface (MTS) on top of the LC layer reduces the resonance frequency and increases the sensitivity to the voltage biasing.

Metasurface Antenna Design

Gabriele Minatti, Francesco Caminita and Enrica Martini (University of Siena, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Stefano Maci (University of Siena, Italy)

This paper summarizes the design method for planar antennas based on modulated metasurfaces (MTSs). These antennas work on a transformation of a cylindrical surface wave (SW) into a leaky wave (LW) through the interaction with the boundary conditions (BCs) imposed by the MTS. The synthesis process allows (i) for determining the BCs that the MTS has to impose in order to reproduce a general aperture field and (ii) for estimating the amount of the input SW power transformed in LW power. Numerical examples are provided as support to the discussion.

Numerical Dispersion and Stability for Three-Dimensional Cylindrical FDTD near the Axis of Rotation

Mohammed F Hadi (Colorado School of Mines, USA & Kuwait University, Kuwait); Atef Elsherbeni (Colorado School of Mines, USA)

The finite-difference time-domain method, when applied in cylindrical coordinates, requires special attention when used in close proximity to a modeled structure's axis of rotation. This paper details the derivation of the numerical dispersion relation and stability criterion of this algorithm. This analysis is instrumental in quantifying simulation error sources and in designing the various ancillary modeling tools.

Properties of Antennas Made with Selective Ag Metallization via Spraying

Arnaud Jammes, Michael Petisme and Koen Staelens (Jet Metal Technologies, France)

This paper starts with the description of a new direct chemical plating method for silver, called the JET METAL (JMT) process and of the JET SELECTIVE process, which allows to obtain a selective metallization on any substrate which can be metallized with the JET METAL process. This technology is based on spraying separately an aqueous solution containing silver metallic ions together with a CMR free, aqueous based reducing agent. This process allows to plate chemical silver at 12 µm/hour at room temperature and at ambient pressure and is already used in industrial processes for metallizing plastics, composites and non-conductive materials in general and this in different formats (3D pieces, 2D foils, …). In the second part, results obtained with metallized antenna patch realized with the process described above are shown and discussed.

Design of Reflective Phase-Shifting Surface for Generating Electromagnetic Vortex Wave

Shixing Yu and Long Li (Xidian University, P.R. China)

A new design of reflective phase-shifting surface for generating an orbital angular momentum (OAM) vortex wave in the radio frequency domain is presented in this paper. The reflective phase-shifting surface consists of single-layer square patches periodically arranged. Theoretical formulations of phase-shift distributions are deduced and used to design the reflective phase-shifting surface producing vortex radio waves. A prototype is designed and simulated to validate the theoretical analysis at 5.8GHz. The simulation results verify that the vortex waves with different OAM mode numbers can be flexibly generated by using the proposed reflective phase-shifting surface. The proposed method paves a way to generate the OAM vortex waves for radio and microwave wireless communication applications.

A Simple and Effective Microwave Invisibility Cloak Based on Frequency Selective Surfaces

Pedro Yuste, Juan M. Rius, Jordi Romeu and Sebastian Blanch Boris (Universitat Politècnica de Catalunya, Spain); Alexander Heldring (Polytechnical University of Catalunya, Spain); Eduard Ubeda (Universitat Politècnica de Catalunya (UPC), Spain)

This paper presents the design, simulation, manufacturing and testing of a simple invisibility cloak based on a frequency selective surface (FSS). The work is focused on cloaking an electrically thin dielectric cylinder with an easy to manufacture FSS made of copper strips glued to the cylinder surface. In contrast to many papers in the literature, the full procedure from formulation to measurement results is presented here. An original approach to obtain the effective surface impedance of the cylindrical FSS from either simulated or measured far fields is introduced. The measurement results show excellent and relatively wide band performance of the cloak prototype.

Low-profile High Gain Antenna Using Patch-patterned Ferrite Metasurface

Jae-Gon Lee and Jeong Hae Lee (Hongik University, Korea)

A novel low-profile high gain antenna using a ferrite metasurface is proposed and designed. The high gain antenna is composed of a patch antenna designed on the perfect electric conductor (PEC) ground plane and the patch-patterned ferrite metasurface. The patch-patterned ferrite metasurface is utilized as a partially reflective surface (PRS) of a patch antenna to increase its gain. A ray theory approach is employed to explain and design the high gain antennas having various heights. The reflection phase of the ferrite metasurface can be controlled by the dimension of a patch on ferrite. In this paper, we have designed the ferrite metasurface having a reflection phase of -90 at the operation frequency of the patch antenna, so that we have designed the high gain antenna with a height of lambda/8.

A Ridge Gap Waveguide Fed Apperture-Coupled Microstrip Antenna Array for 60 GHz Applications

Davood Zarifi (University of Kashan, Iran)

This paper deals with the design of patch antenna arrays with Ridge Gap Waveguides (RGW) feed networks at 60-GHz band. An array of 64 radiating elements are designed and simulated to demonstrate the good performance of the proposed array. The proposed antenna shows the gain up to 22.6 dBi, efficiency higher than 80% and an

impedance bandwidth of 13% covering 59-67 GHz. The results are valuable for the design and evaluation of wideband planar antenna arrays at millimeter-wave frequencies.

A Millimeter Wave Antenna with Wide Bandwidth by Using Dielectric Polarizer

Wang Kai Xu and Hang Wong (City University of Hong Kong, Hong Kong)

This paper presents a wideband circularly-polarized millimeter-wave antenna. It consists of a horn antenna and a dielectric substrate. The horn antenna have a wide impedance bandwidth from 50 to 100 GHz for the reflection coefficient below-10 dB. The dielectric substrate is placed above the horn antenna and some rectangular holes are etched from the dielectric substrate to act as a polarizer to transform the polarization of the antenna radiation from linear to circular. The proposed polarizer yields a wide axial ratio bandwidth of 44% from 62 to 97 GHz for the axial ratio below 3 dB. The maximum gain of the antenna can reach to 15 dbic. The proposed polarizer is fabricated by using 3D technology with simple design and low cost.

Antireflective Textured Silicon Optics at Millimeter and Submillimeter Wavelengths

Cecile Jung-Kubiak (NASA-JPL, Caltech, USA); Jack Sayers, Matt Hollister, Arjun Bose, Hiroshige Yoshida, Luke Liao and Jonathan Wong (Caltech, USA); Simon Radford (Caltech, SAO, USA); Goutam Chattopadhyay (JPL, USA); Sunil Golwala (Caltech, USA)

Silicon optics with broadband antireflective (AR) treatments are being developed for millimeter and submillimeter-wave applications, using high resistivity silicon wafers and combined photolithography and deep reactive ion etching (DRIE) techniques. We report on the design, fabrication and testing of single-layer lenses, as well as double-layer lenses, at 250 GHz.

Design of Multiband Segmented Loop Antenna for Unmanned Aerial Vehicle Applications

Dogu Kang and Jaehoon Choi (Hanyang University, Korea)

A multiband segmented loop antenna for unmanned aerial vehicle applications is proposed. The antenna is composed of a segmented loop including eight segments, a patch element, and a shorting strip. The antenna operates with an omnidirectional radiation at 956 MHz because the eight segments are electrically connected with seven capacitive reactances. Due to the addition of both the patch element and shorting strip, the impedance matching characteristic is improved. The proposed antenna has the multiband performance covering GPS L1, GSM1800, GSM1900, UMTS, LTE2300, LTE2500, and 2400 MHz ISM bands. The antenna has quasi-omnidirectional radiation over the above listed frequency bands.

Reduced Ground Plane Aperture-Coupled DRA Fed by Slotted Microstrip for Ultra-Wideband Application

Chemseddine Zebiri (Ferhat Abbas University of Setif, Algeria); Djamel Sayad (University of 20 Aout 1955 - Skikda, Algeria); Nazar Ali (Khaifa University, United Arab Emirates (UAE)); Mohamed Lashab (University of 20 Aout 55, Skikda, Algeria); Fatiha Benabdelaziz (Université de Mentouri, Constantine, Algerie, Algeria); Raed A Abd-Alhameed (University of Bradford, United Kingdom); Issa Elfergani and Jonathan Rodriguez (Instituto de Telecomunicações, Portugal)

Two dielectric resonators antenna (DRA) fed through slotted microstrip line for a wideband application is proposed. The two cylindrical DRs are asymmetrically situated with respect to the rectangular coupling aperture center with a defected ground plane. By optimizing the design parameters, two antenna configurations have been achieved: the first covering an impedance bandwidth of about 57%, from 8.02GHz to 14.55 GHz with power gain of 10dBi, and the second having an impedance bandwidth of about 54%, from 8.5GHz to 14.7 GHz, and a power gain of 12dBi. Results of the proposed antennas are presented and discussed.

A Low-profile Parallel Plate Waveguide Slot Antenna Array for Dual-polarization Application

Xianlong Lu, Xiaochuan Wang and Wenzhong Lu (Huazhong University of Science and Technology, P.R. China)

This paper proposes a dual-polarization parallel plate waveguide (PPW) slot antenna array which has the advantages of high efficiency and low-profile. The antenna array is realized in the multilayer structure. The H-plane waveguide arrays in the low layer and the 2×2-element subarray in the upper layer are employed as the feed networks and radiating part, respectively. An 8×8-element array with height of less than 1.2λ0 is designed and simulated. The simulated results show that the bandwidths (|S11|<-10 dB) are about 5.0% (12.05-12.67 GHz) for x-direction and 4.1% (12.08-12.58 GHz) for y-direction polarization. The isolation is better than 25 dB. The antenna efficiencies of more than 80% for both two polarizations are achieved at 12.3 GHz.

Sinusoidal Time-Modulated Uniform Circular Array for Generating Orbital Angular Momentum Modes

Timothy Drysdale (The Open University, United Kingdom); Ben Allen (University of Oxford & Network Rail, United Kingdom); Ernest Okon (Thales UK, United Kingdom)

DRAFT VERSION Time Modulated Uniform Circular Arrays (TMUCA) can produce Orbital Angular Momentum (OAM) modes, but typically suffer from leakage of energy into all available OAM modes. This prevents more than one data channel being encoded using OAM modes, and thus prevents full exploitation of the potentially available spectral efficiency. This paper proposes a modified approach that overcomes this limitation, by adopting a time-modulation scheme that relies only on the fundamental harmonic of the time-switching signal, eliminated unwanted spectral and spatial mode leakage. Simulations are presented to support the proposal.

Design of Cassegrain Reflectarray Antenna with Compact Ring Focus Feed

Geng-Bo Wu (UESTC, P.R. China); 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); Chao Ma (UESTC, P.R. China)

A Cassegrain reflectarray antenna using compact ring focus feed is introduced in this paper. The ring focus is formed by the dielectric guide sub-reflector, where the impedance matching can be achieved by adjusting the dimension of the dielectric guide. Also, the actual incidence angles of the coming waves are considered in the

design of the reflectarray. A 572-element Cassegrain reflectarray with a low focus-to-diameter rate (F/D) of 0.2 has been designed and simulated. The numerical results demonstrate that this flat Cassegrain reflectarray has achieved aperture efficiency of 33.3% at 12GHz.

A Compact UWB CPW-fed Antenna with Inverted L-Shaped Slot for WLAN Band Notched Characteristics

Athar S. Fazal (CIIT, Pakistan); Usman Nasir (COMSATS Institute of Information Technology, Pakistan); Bilal Ijaz (CIIT, Pakistan); Khurram S Alimgeer (COMSATS Institute of information Technology, Pakistan); Muhammad Farhan Shafique (COMSATS Institute of Information Technolgy, Pakistan); Raed Shubair (Khalifa University (KU) & Massachusetts Institute of Technology (MIT), United Arab Emirates (UAE)); Muhammad Saeed Khan (COMSATS Institute of Information Technology, Pakistan)

The purpose of this draft is to introduce a compact CPW-fed antenna with WLAN band notched characteristics. For band notched characteristics, an inverted L-shaped structure is used on the surface of radiator. The proposed design has overall size of 25 x 25 x 1.6 mm3 and covers the entire UWB spectrum from 3.02 GHz to 11.34 GHz except the notch band from 4.9 GHz to 6.2 GHz. High concentration of surface current is shown on the inner side of antenna surface and inverted L-shaped stub, when the design is simulated at 5.5 GHz to show the band notch affect. The simulated results in terms of return loss, surface current distribution and VSWR exhibit good antenna performance over the complete spectrum. The validity of the proposed design is also shown by comparing the simulated results with the measured results.

Mutual Coupling Reduction in Dielectric Resonator MIMO Antenna Arrays Using Metasurface Orthogonalize Wall

Mohammadmahdi Farahani (INRS University, Canada); Mohammad Akbari (Concordia University & Montreal, Canada); Mourad Nedil (UQAT, Canada); Tayeb A. Denidni (INRS-EMT, Canada)

An effective technique for reducing the mutual coupling between mm-wave dielectric resonator antennas (DRA) using a novel metasurface is investigated and presented. This is achieved by embedding a metasurface wall between the two DRAs, which are placed in H-Plane. Using the proposed metasurface, the TE modes of the antenna become orthogonal which reduces the mutual coupling between the two DRAs. The proposed metasurface wall is composed of 5×4 unit cells along the E-Plane. The mutual coupling is reduced between 4 to 20 dB when the proposed metasurface wall is placed between the antennas. Moreover, the proposed metasurface wall does not have significant impact on the antenna radiation pattern.

Human Exposure to Wireless Power Transfer Systems: a Numerical Dosimetric Study

Rosanna Pinto (ENEA, Italy); Vanni Lopresto (ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy); Antonino Genovese (Italian National Agency for New Technologies Energy and Sustainable Economic Development & ENEA, Italy)

Wireless Power Transfer (WPT) technology is one of the most promising application for charging the batteries of electric vehicles. In this framework, the exposure assessment of human body to the stray electromagnetic fields emitted by WPT devices represents a critical issue. In this paper, a methodology for the numerical assessment of the Electric (E)-field induced by WPT systems in exposed people was set up in order to obtain reliable dosimetric results, avoiding high computational costs for simulations. A numerical dosimetric study was carried out to evaluate the electric (E)-field induced in both a homogeneous ellipsoid phantom and in an anatomical human model exposed to a WPT system prototype (delivered power 560 W). Two exposure scenarios were considered employing the anatomical model: the maximum 99th percentile of the induced E-field value in central nervous system was 0.05 V/m and the maximum current density value in the head was 30 mA/m2.

Planning Broadband Train-To-Ground Systems and WiFi Deployments in Subways: Overview and Results

Juan Moreno (Metro de Madrid S.A. & Universidad Politécnica de Madrid, Spain); Carlos Hernández and Carlos Rodríguez Sánchez (Metro de Madrid S.A., Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain)

Although available for more than ten years, broadband train-to-ground (BTTG) systems have recently become very popular. Railway operators and stakeholders are pressuring to include many communication services inside the train (VoIP, HD-CCTV, onboard WiFi for passengers, signaling, etc.) and to replicate the operational model for stations with remote maintenance and control. In this paper we provide a planning procedure and a discussion for BTTG systems from an industrial perspective. We also provide measurements inside a train car to obtain a channel model useful for WiFi design, and BTTG measurements of signal strength and throughput. Finally, some details about the environment (for testing purposes) are as well mentioned.

Experimental Analysis of Aligment Impact in Short Communications at 300 GHz

Maria-Teresa Martinez-Ingles (University Centre of Defence at the Spanish Air Force Academy, MDE-UPCT, Spain); Davy P Gaillot (University of Lille 1, France); Jose-Maria Molina-Garcia-Pardo, José-Víctor Rodríguez, Juan Pascual-García and Leandro Juan-Llacer (Universidad Politécnica de Cartagena, Spain); Martine Liénard (University of Lille, France)

This work shows preliminary results at 300 GHz, where the effect of misalignment between directive antennas is studied. It is shown than 2 degrees results in a 3 dB loss. Also, multiple specular reflections are found between both antennas at this mmW frequency in such short commutations.

A Copulas-Based Time Series Synthesizer for Mobile Satellite Communications Operating Above 10 GHz

Charilaos Kourogiorgas and Athanasios D. Panagopoulos (National Technical University of

Athens, Greece); Rodoula Makri (ICCS, Greece)

In this paper, a synthesizer of rain attenuation time series is presented for a mobile satellite communications system operating at Ku-band and above. In order to support high data rates for mobile terminals in various regions, satellite communication systems could migrate to higher frequency bands. However, the rain attenuation first and second order statistics in mobile satellite systems differ to the fixed stations. Here, an existing copulas-based synthesizer is modified to generate rain attenuation time series and reproduce the statistics of a mobile link under rain. New parameters are extracted and the difference between the first and second order statistics are shown. More particularly, the difference on Kendall's tau parameter, time diversity gain and fade slope statistics between a mobile user and fixed user for a specific scenario are examined.

Statistical Analysis of Instantaneous Frequency Scaling Factor as Derived from Optical Disdrometer Measurements at V/W Bands

Michael Zemba and James Nessel (NASA, USA); Nicholas Tarasenko and Steven Lane (Air Force Research Laboratory, USA)

Since October 2015, NASA Glenn Research Center (GRC) and the Air Force Research Laboratory (AFRL) have collaboratively operated an RF terrestrial link in Albuquerque, New Mexico to characterize atmospheric propagation phenomena at 72 and 84 GHz. The W/V-band Terrestrial Link Experiment (WTLE) consists of coherent transmitters at each frequency on the crest of the Sandia Mountains and a corresponding pair of receivers in south Albuquerque. Alongside the receivers is an optical disdrometer which yields droplet size and velocity distributions (DSD, DVD). In particular, the DSD can be used to derive an instantaneous scaling factor (ISF) by which the measured data at one frequency can be scaled to another - for example, scaling the 72 GHz to an expected 84 GHz timeseries. Given the availability of both the DSD prediction and the directly observed 84 GHz attenuation, WTLE is thus uniquely able assess DSD-derived instantaneous frequency scaling at the V/W-bands.

Multimode Extraction from Dielectric Loaded Waveguides via Method of Moments

Ahmet Aydoğan (Marmara University & Istanbul Technical University, Turkey); Funda Akleman (Istanbul Technical University, Turkey)

Multimodal interactions for inhomogeneously loaded rectangular waveguide are examined. Method of Moments (MoM) is utilized to obtain the scattered field data. Validation of the approach is performed by comparison with mode matching technique.

On the Use of Convex Optimization for Electromagnetic Near-field Shaping

Ioannis Iliopoulos (IETR, University of Rennes 1, France); Benjamin Fuchs (University of Rennes 1 - IETR, France); Ronan Sauleau (University of Rennes 1, France); Philippe Pouliguen (DGA/Direction de la Stratégie, France); Patrick Potier (DGA/Maîtrise de l'Information, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

Near-field shaping at microwave or millimeter wave frequencies is an emerging field of study, able to accelerate a variety of technologies. Applications from sensing to medical imaging will benefit from accurate near-field shaping methods. In this communication, the use of convex optimization to shape the near field of a flat radiating aperture is investigated. The proposed approach that is known to provide optimal solutions is compared to existing near-field shaping methods.

Enhancing Breast Cancer Imaging at Millimeter Waves Using Focusing Techniques

Ioannis Iliopoulos (IETR, University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Ronan Sauleau (University of Rennes 1, France); Philippe Pouliguen (DGA/Direction de la Stratégie, France); Patrick Potier (DGA/Maîtrise de l'Information, France); Luca Perregrini and Marco Pasian (University of Pavia, Italy)

Medical imaging using electromagnetic waves is a promising field of study, due to its non invasive nature and relatively low cost. Typically, it is pursued at frequencies in the microwave regime to provide adequate penetration depth. However, an increase of the frequency of operation is beneficial in order to improve the resolution, but it is accompanied by increased tissue losses. In this work we investigate the possibility to increase the penetration depth of systems for breast imaging at the lower bound of millimeter waves (30 GHz). The proposed technique consists of a focusing of the field, which provides an important improvement at the achieved imaging depth.

Asymmetric Split Ring Nanosandwich for Refractive Index Sensing

Sara Magdy Kandil (Zewail City for Science and Technology, Egypt); Islam Eshrah (Cairo University, Egypt); Inas El Babli (Faculty of Engineering, Cairo University, Egypt); Ashraf Badawi (Zewail City for Science and Technology, Egypt)

In this paper, we investigate the effect of applying asymmetry to the split ring nanosandwich on its refractive index sensitivity and optical response. Three different asymmetry configurations are studied which are: rotating the upper split ring, tapering the edges and stacking up additional layers to the nanosandwich structure. Each of these configurations shows a significant influence on the sensitivity and spectral response. They also excite different E-field profiles with diverse enhancement locations which make the asymmetric split ring nanosandwich efficient for biosensing applications. A maximum sensitivity of 1953 nm/RIU is obtained at 3916 nm wavelength.

A Novel Implantable Printed Dipole with Improved Gain

Motti Haridim (Holon Institute of Technology, Israel); Or Keren and Adi Amitt (Holon Institute of Technology); Mehdi Azadmehr (University College of Southeast Norway)

This paper presents a novel planar implantable dipole antenna operating at the Medical Device Radio Communications Services band (401-406 MHz). The proposed antenna's physical volume is 19.8 mm3. The antenna exhibits gain and efficiency improvement over similar implantable dipoles through combining a square spiral with a short plain strip in each dipole arm. The antenna's gain is -24.6 dB, and its efficiency is 0.09%. SAR simulation results are also presented.

Design and Characterization of a Miniaturized Implantable UHF RFID Tag Based on LTCC

Technology

Aleix Garcia-Miquel (University of Barcelona, Spain); Beatriz Medina-Rodríguez (Francisco Albero S.A., Spain); Neus Vidal (University of Barcelona, Spain); Francisco Ramos (Francisco Albero S.A., Spain); Elisenda Roca (Instituto de Microelectronica de Sevilla, Spain); Jose López-Villegas (University of Barcelona, Spain)

This paper presents the design and characterization of a novel, compact, multilayer, passive UHF-RFID tag solution for implantable biotelemetry based on low-temperature co-fired ceramic (LTCC) technology. A spiral planar inverted-F antenna (PIFA) was matched to the UHF integrated circuit (IC) impedance by an inductor line. The LTCC process allowed the IC to be embedded in a sealed cavity. Simulations and measurements of the reflection coefficient and the tag range were carried out when the RFID tag was implanted in the center of a 10 cm cubic skin phantom. The dimensions of the prototype were 8x7x2 mm3, leading to a total volume of 112 mm3. Results indicated a 6 dB bandwidth of 39 MHz and 84 MHz for simulations and measurements, respectively, and a tag range of approximately 10 cm.

Miniaturized Dual-Wideband Circular Patch Antenna for Biomedical Telemetry

Abdelrahman Mohamed (King Fahd University of Petroleum and Minerals, Saudi Arabia); Mohammad S. Sharawi (King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia)

A compact dual-wideband circular patch antenna is designed for implanted biomedical data telemetry systems. Several miniaturization techniques were applied to have the resonance at the desired frequencies. The antenna has a radius of 7.5 mm, a thickness of 1.92 mm and a total volume of 340 cubic millimeters. The antenna covers MedRadio (401-405 MHz), MICS (402-405 MHz), and ISM (433.2-434.8 MHz, 2.4-2.5 GHz) bands with a total bandwidth of 685 MHz. The -10dB bandwidth were 351-476 MHz (125 MHz) and 2.26-2.82 GHz (560 MHz). The antenna performance was evaluated in a human tissue model.

Aperture-Coupled Wearable Antenna with Miniature Feeding Network

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

An aperture-coupled wearable antenna with a miniature feeding network is proposed. In wearable systems, it allows to minimize the dimensions of the rigid Printed Circuit Board (PCB) carrying the electronics and feeding the textile antenna, optimizing the comfort of the user. Simultaneously, it avoids probe feeding, that requires a single soldering point that has a huge risk of being broken with time due to user movements. Since the aperture is implemented on the PCB, it can be fabricated with excellent tolerances. The antenna achieves a miniature feeding network with dimensions of 10 mm × 10 mm (0.0817 λ × 0.0817 λ at 2.45 GHz), while maintaining a good performance in the ISM band. Simulations and experiments agree well, validating the functioning of the antenna.

434 MHz ISM Band Antenna for in-Body Biotelemetry Capsules

Denys Nikolayev (Institute of Electronics and Telecommunications of Rennes, France); Maxim Zhadobov (University of RENNES 1, France); Pavel Karban (University of West Bohemia, Czech Republic); Ronan Sauleau (University of Rennes 1, France)

We propose a versatile 434 MHz in-body capsule antenna suitable for ingestible and variety of implantable applications. The low profile conformal antenna is synthesized using a hybrid analytical-numerical approach and optimized for robust operation at 434 MHz inside a 17 mm long biocompatible encapsulation (7 mm diameter). The antenna remains matched below -10 dB in wide range of body tissues (from 42% of muscle electromagnetic properties up to the maximum tissue electromagnetic properties). A realized gain is -22.4 dBi and radiation efficiency reaches 0.4%. The radiation performance of the proposed antenna exceeds most of counterparts whereas its impedance characteristics are more robust.

Wireless Power Transfer: Are Children More Exposed Than Adults?

Mohsen Koohestani (Institut d'Electronique et de Télécommunications de Rennes - Université de Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Maxim Zhadobov (University of RENNES 1, France)

Aiming at comparing the exposure levels among children and adults, this paper investigates the exposure due to a representative wireless power transfer system in three different human body models, i.e. adult male and female as well as a child. A dosimetry study has been performed to evaluate the exposure levels with respect to the ICNIRP basic restrictions. Differences in terms of dosimetric quantities (E$_{99}$, J$_{1cm^2}$, and local and whole body SAR) has been assessed and reported. Maximum allowable input power has been computed for a representative scenario. It has been found that, for the considered scenario, the exposure due to a resonant WPT system in a child is the same or lower than in an adult. Moreover, the impact of the body dimensions is more pronounced for peak RMS values of E$_{99}$ and J$_{1cm^2}$ compared to those obtained for SAR$_{10g}$ and SAR$_{wb}$. J$_{1cm^2}$ is found to be the most ...

Study on the Compromise Between Resolution and Attenuation for Breast Imaging Systems

Simona Di Meo, Andrea Martellosio, Marco Pasian, Maurizio Bozzi, Luca Perregrini, Andrea Mazzanti and Francesco Svelto (University of Pavia, Italy); Paul Summers, Giuseppe Renne, Lorenzo Preda and Massimo Bellomi (European Institute of Oncology, Italy)

Microwave and mm-wave imaging systems for breast cancer detection are pursued to provide an additional technique with respect to current approaches, mostly based x-rays, ultrasounds, and magnetic resonance. The use of non-ionizing radiation and the relatively low cost are among the most important advantages, but often with resolution or attenuation below expectations for microwave and mm-wave systems, respectively. This paper presents a study based on experimental results, for the first time in the frequency range 0.5-50 GHz, where the potential resolution and propagation losses of breast cancer imaging systems are addressed. In particular, the dielectric properties of the human breast are derived from a systematic clinical campaign involving more than 50 patients, who provided more than 200 ex-vivo tissue samples. As an example, the comparison between a system intended to work at 5 GHz and a system designed at 30 GHz is addressed.

Design of 2x2 Array Antenna with Harmonic Suppression Using T-Shape DGS and Spurline

Nurzaimah Zainol, Zahriladha Zakaria and Maisarah Abu (Universiti Teknikal Malaysia Melaka, Malaysia); Mawarni Mohamed Yunus (Universiti Teknologi Malaysia, Malaysia); Eliyana Ruslan (Universiti Teknikal Malaysia Melaka, Malaysia)

In this paper, a new design of 2x2 array antenna with harmonic suppression using defected ground structure (DGS) and spurline has been developed to suppress the undesired signals at harmonic frequency. The results achieve a very good return loss which peaked up to -33.44 dB at 2.45 GHz operating frequency which makes it great promising applications for RF/Microwave energy transfer particularly in suppressing the harmonic that degrade the system performance. The antenna has an extremely high gain which achieved a 14.20 dB with a strong directional radiation pattern; and total efficiency achievement of the 2x2 antenna array is up to 98.86%. Besides that, the excitation of harmonic signals have been suppressed effectively from -29.19 dB to -7.77 dB at frequency of 3.24 GHz and achieved a wider stopband up to 8 GHz. Experimentally, the measured and simulated results are found in an excellent agreement.

Design of Planar Implantable Compact Antennas for Vaginal Sensor for Early Detection of Calving

Imen Ben Trad and Jean-marie Floch (IETR-INSA Rennes, France)

Two implantable antennas radiating at the Industrial, Scientific, and Medical (ISM) frequencies 868 and 915 MHz were proposed to be employed in a vaginal sensor. These structures were developed in the context of the industrial project "Vel'Phone sensor" funded by Medria, a French company for monitoring services. The compact antennas consist on a meander patch and a metamaterial (MTM) -inspired monopole. Both antennas were optimized in free space and in a model of the environment faithful to reality (inside the cow vagina). Prototypes were manufactured and tested using liquid phantom. We proved the potential of the overall system integrated with an electronic card and biocompatible material in real conditions. Simulated and measured results are presented and discussed.

Towards Optimal Noise Properties of NMR Antenna-Receiver Chain

Petar Kolar, Silvio Hrabar and Mihael Grbic (University of Zagreb, Croatia)

A role of a small loop antenna, that acts as a probe in standards NMR systems, is reviewed. It is shown that the noise properties of a whole system are not always dictated just by proper resonant matching of the antenna and the use of high-quality pre-amplifier (as it is usually believed). Actually, the losses and mismatch of all other passive components may have a serious impact on the overall chain sensitivity. A simple theoretical and experimental investigation has shown that careful design of the NMR antenna-receiver chain can substantially decrease the overall noise figure, and therefore increase the system sensitivity.

Wideband Characterization of a Diluted Water Ferrofluid in Presence of a Polarizing Magnetic Field for Application in Biomedicine

Gennaro Bellizzi (University of Naples Federico II, Italy); Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Ovidio Mario Bucci (University of Naples, Italy)

In this paper we summarize the results of a broadband microwave characterization of the magnetic susceptibility of a diluted water suspension of magnetic nanoparticles, when subject to a polarizing magnetic field of variable strength. In addition, we also present the results of fitting the measured susceptibility with a superposition of relaxation and resonance dispersion models, carried out to get an analytical description of the magnetic response over the entire investigated range of frequencies and polarizing fields. The analysis of the fitting results has shown expected but also unexpected results, whose physical nature deserves further investigation. The presented measurement and fitting results are of particular interest for the implementation and the optimization of some emerging biomedical applications of microwaves and magnetic nanoparticles, such as microwave imaging for the breast cancer diagnostic.

Application of S Parameter to the Inverse Scattering Problem

Yoshihiko Kuwahara (Shizuoka University, Japan)

This paper proposes a method to apply the scattering parameter in the inverse scattering problem. Many researchers may use a vector network analyzer (VNA) as the transceiver in the microwave tomography system. In general, the integral equation for the inverse scattering problem describes relations between the scattered, total, incident field, and the permittivity. In this equation, we cannot apply the scattering parameters, directly. To overcome the problem, we introduce the reciprocity theorem and the circuit theory. The integral equation is rewritten to an equation that relates the observed feed voltage with the permittivity. The effectiveness of the method is demonstrated by a numerical experiment for the microwave mammography

Breast Phantom with a Conductive Skin Layer and Conductive 3D-Printed Anatomical Structures for Microwave Imaging

Bernd Faenger (University Hospital Jena & Institute of Diagnostic and Interventional Radiology, Germany); Sebastian Ley and Marko Helbig (Technische Universität Ilmenau, Germany); Jürgen Sachs (Ilmenau University of Technology, Germany); Ingrid Hilger (University Hospital Jena, Germany)

We present a breast phantom for experimental medical microwave imaging. The phantom structures separating the tissue mimicking liquids are 3D-printed based on conductive materials. The skin is casted by silicone composites with carbon powder and graphite. In comparison to 3D printing with common plastic, this approach allows the simulation of anatomical breast structures with improved dielectric characteristics.

Design of FSS Unit-cell for Energy Concentration on Deep-seated Human Tissue

Woo Cheol Choi, Seonho Lim and Young Joong Yoon (Yonsei University, Korea)

A FSS which allows for a concentration of the EM energy on a deep-seated tissue in the human body is proposed. The unit-cell can change the phase response of the EM wave in a wide phase range, while maintaining the minimum variation of the transmission magnitude. By integrating the unit-cell into the phased-array configuration,

the EM energy can be localized into the deep-seated tissue by compensating the phase-delays for different electrical lengths between the FSS-array and the desired target. It leads to the constructive interference of the EM field at the target tissue, so as to deliver strong energy into the human body. The unit-cell consisting of the three-layer metallization is embedded in the water-bolus which provides the optimal condition for the wave-penetration into the complex dielectric media. The FSS unit-cell is analyzed by using the equivalent circuit model and the transmission characteristic is evaluated on the phantom (human body).

Metasurfaces with Positive Reflection Phase Gradients for Broadband Directive Emission

Riad Yahiaoui (Université Paris Ouest Nanterre la Défense, France); Thtreswar Beeharry (UPOND, France); Shah Nawaz Burokur (LEME, France); Patricia Grassin (UPOND, France); Habiba Ouslimani (Université Paris Ouest Nanterre La Défense, France)

Recently, the concept of partially reflecting surface (PRS) with positive reflection phase gradients has been proposed for the design of wideband cavity antennas. In this work, we numerically and experimentally implemented this idea and demonstrated a broadband and highly directive Fabry-Pérot cavity antenna (FPCA) with dual layer PRS at microwaves. Good performance of impedance matching bandwidth (S11 < -10 dB), and a peak directivity of about 17 dB in simulation and less in measurements at around 10 GHz were achieved.

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Radars / Regular Session / Antennas

Room: Poster Sessions: Corridor Paris

Chairs: Claes Beckman (KTH Royal Institute of Technology, Sweden), Bernard Uguen (University of Rennes I, France)

Wideband Meachanical Scanning Lens Antenna at Ku-Band

Peng-Yu Feng (UESTC, P.R. China); 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 mechanical beam steering lens antenna was proposed in this paper. Referring to the operating principle of Risley beam steering system, a fixed beam array antenna was utilized to excite the dielectric wedge lens at Ku-band. By controlling the relative rotation between the feed and the lens, the whole antenna system can scan to ±50° in all directions. The whole profile was integrated to minimum by reducing the feeding distance and the attendant strong coupling effect was suppressed exploiting the multiple layers matching technique. The prototype confirms the feasibility of using array antenna to excite the lens for achieving a low profile, wideband, wide mechanical scanning and high aperture efficiency beam steering antenna.

A Wideband Wide-angle Scanning 1-D Microstrip Patch Array

Xia Run-Liang and Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China)

Controlling the mutual coupling between array elements is one of the key problems in phased array designs. In this letter, a wideband decoupling network is proposed to suppress the mutual coupling between adjacent array elements. It is shown that the employment of the proposed network leads to a significant improvement of the operating bandwidth under the condition of maintaining a wide scan range, compared with conventional feeding techniques. In this manner, a 1 × 16 stack patch phased array prototype with the proposed decoupling network was fabricated. Measurement results agree well with simulated ones and indicate the effectiveness of the proposed approach in designing a wideband wide-angle scanning phased array.

Increasing Accuracy of Angular Measurements Using UWB Signals

Yury Shestopalov (University of Gävle, Sweden)

We show that dispersion characteristics of antenna patterns should be taken into account when developing systems using UWB signals. The accuracy of measurement of angular coordinates of objects using UWB pulses is increased by optimizing their shape based on known characteristics of the antenna system and at least partially known characteristics of the investigated signal source. Optimization algorithms allow to minimize the width of the directional pattern for a given level of the useful signal.

The Effects of Geometric Scattered Signal Waveform Modeling on Target Identification Performance

Alper M Selver (Dokuz Eylul University, Turkey); Mustafa Secmen (Yasar University, Turkey); Yesim E Zoral (Dokuz Eylul University, Turkey)

Target identification from scattered signals using time domain techniques depend significantly on the waveform. Recently, a structural feature set is proposed which encounter structural properties of the waveform and collects local extrema points to model the scattered signal via triangularization. Then, using this piecewise model, it extracts several morphological features and employs them for target identification through classification. This study expands that approach by modeling the scattered signal with various geometric shapes and accordingly, by enriching the feature set. Such an approach requires careful representation of the waveform model since more than one morphology is considered to represent valleys and hills of the waveform. The effects of this new approach are observed by applications on conducting and dielectric spherical target having different size.

Comparison of Scattered Signal Waveform Recovery Techniques Under Low SNR for Target Identification

Alper M Selver (Dokuz Eylul University, Turkey); Mustafa Secmen (Yasar University, Turkey);

Yesim E Zoral (Dokuz Eylul University, Turkey)

Target identification from scattered electromagnetic waves is a difficult problem especially at low SNR levels, which prevents extraction of distinguishable information. When a scattered signal is corrupted by noise, it should be recovered before further processing such as feature extraction and classification. This recovery can be performed in time domain, frequency domain or via time-frequency analysis. In this study, three important techniques are used for distortion correction and their performances are compared. The analyses are performed with both simulated and measured data from various conductor and dielectric targets having different size, geometry and material type.

Some Features of Electromagnetic Scattering by Radially Inhomogeneous DNG Spheres

Alina Gabdullina (Moscow Institute of Physics and Technology, Russia); Olga Smolnikova (Company Radiophyzika, Russia); Sergei P. Skobelev (Radiophyzika, Russia)

A modification of the hybrid projection method developed for analysis of electromagnetic wave scattering by radially inhomogeneous sphere is described. The method is validated for convergence, comparison with appropriate results available in the literature, and for fulfillment of the optical theorem. The method is applied for studying plane wave scattering by Luneburg and Eaton-Lippmann lenses with negative permittivity and permeability. Geometric-optic ray tracing and some results for bistatic and monostatic scattering cross-section for the indicated doubly negative (DNG) lenses of various radii are compared to those of their conventional dielectric analogs.

Some Features of Shaping Narrow Flat-Topped Radiation Patterns by Overlapped Subarrays in Limited-Scan Waveguide Phased Array Antennas

Sergei P. Skobelev (Radiophyzika, Russia); Ivan Makeev (Moscow Institute of Physics and Technology, Russia)

An infinite periodic array of multimode parallel-plate waveguide sections of finite length, each of which is excited by TM modes from a pair of input waveguides, is considered. The array performance is analyzed by the method of projection mode matching on the boundaries of the regions. A few networks of the array excitation are considered for forming overlapped subarrays shaping sector flat-topped radiation patterns. Some numerical results characterizing effectiveness of application of the networks involved for different values of the array element spacing including large enough corresponding to narrow patterns are presented.

Accuracy Improvement of Near-to-Far-Field Transformation in FDTD Calculation

Yiwei He (Osaka Electro-communication University, Japan); Qinglian Guo (Kanazawa Institute of Technology, Japan)

It has been indicated that the accuracy of near-to-far- field (NTFF) transformation in a FDTD computation has a poor accuracy if the cell size is rough than 1/20 wavelength. We investigated the possible reasons that may affect the accuracy of NTFF transformation and found that the averaging approximation of tangential electric and magnetic fields on enclosed Huygens's surface is dominant. In our modified NTFF transformation, the tangential components on the enclosed surface are calculated from the nearby field components with a higher precision. It will be illustrated that the modified method can more accurately calculate the radiation pattern with a cell size of 1/10 wavelength.

Nested Iterative Solutions of Electromagnetic Problems Using Approximate Forms of the Multilevel Fast Multipole Algorithm

Can Onol, Arif Ucuncu, Bariscan Karaosmanoglu and Ozgur Ergul (Middle East Technical University, Turkey)

Nested iterative solutions using full and approximate forms of the multilevel fast multipole algorithm (MLFMA) are presented for efficient analysis of electromagnetic problems. The developed mechanism is based on preconditioning an iterative solution via another iterative solution, and this way, nesting multiple solutions as layers. The accuracy is systematically reduced from top to bottom by using the on-the-fly characteristics of MLFMA, as well as the iterative residual errors. As a demonstration, a three-layer strategy is presented, considering its parametrization for accelerating iterative solutions of perfectly conducting objects. We show that the strategy significantly reduces the solution time, especially for ill-conditioned matrix equations that are derived from the electric-field integral equation.

Optimization of a MIMO Radar Antenna System for Automotive Applications

Claudia Vasanelli and Rahul Batra (Ulm University, Germany); Christian Waldschmidt (Ulm University)

Multiple-Input Multiple-Output (MIMO) radars can improve the angular resolution of automotive radar sensors. In MIMO radars, a critical design parameter is finding the optimal placement of the transmitting and receiving arrays. Indeed, the physical position of the transceivers affects directly the properties of the virtual array. Unfortunately, the inverse mapping from the virtual array to the real transmitter-receiver configuration is still analytically unsolved. In this paper, a genetic algorithm is employed to search the optimal antenna placement. The fitness function exploits the characteristics of the ambiguity function and this allows potentially to control the ambiguity-free region of the antenna system. Numerical and experimental results confirm the suitability of this design procedure.

A Measured FSS Radome with Two Absorptive Bands Separated by One Passband

Weiwei Wu (National University of Defense Technology, P.R. China)

In this paper, a novel FSS radome is developed and measured. This radome has one transparent passband and two absorptive bands. These two absorptive bands are separated by the passband. The radome is manufactured and measured to verify its unique electromagnetic characteristics. In the passband, the gain of the antenna with our radome is only 1~2dB lower than the one of the antenna without any radome. In the absorptive bands, the electric level of the reflected electromagnetic wave from the radome can be 16.5dB lower than the one from a metallic plane with the same size as the radome.

An Efficient Metamaterial-Inspired, Electrically Small Antenna for ISM Band Applications

Sultan Can (Ankara University, Turkey); Kamil Yavuz Kapusuz (Ghent University, Belgium); Asım Egemen Yılmaz (Ankara University, Turkey)

In this study, an electrically small, monopole slot antenna based on near-field resonant parasitic (NFRP) elements composed of metamaterial inspired capacitively loaded loop (CLL) elements is designed and analyzed via a commercial full wave electromagnetic solver. The proposed antenna has an operational frequency of 2.4 GHz and it satisfies the limits of an electrical small antenna (ESA) having a ka value of 0.88. The antenna has a very high efficiency with an overall efficiency value of 95%. The directivity and gain of the proposed antenna is 1.7 dB and 1.45 dB, respectively.

Improving the Radiant Performance of the Antenna with High Impedance Periodic Structure

Guangwei Yang and Jian-ying Li (Northwestern Polytechnical University, P.R. China); Wei Zhang (Northwestern of Polytechnical University, P.R. China)

In this paper, high impedance periodic structure (HIPS) is applied to improve radiation pattern of the antenna element. The working mechanism of HIPS array is investigated. The structure could improve the surface-wave and the broad-beam radiation performance of the individual antenna element. It is benefit for the wide scan performance of the phased array. A microstrip antenna is fabricated and measured. By the comparison to the metal ground plane, the radiation pattern is wider. The measured results of the array coincide with the simulated results.

A Broad-Band Linear-to-Circular Transmission Polarizer Based on Frequency Selective Surfaces

Wei Zhang (Northwestern of Polytechnical University, P.R. China); Jian-ying Li (Northwestern Polytechnical University, P.R. China)

A four-layer square split-rings frequency selective surface is applied for designing a polarization converter. The new proposed polarizer operates in broadband, from 6.4 to 13.7GHz, which can generate circularly polarization waves from incident linearly ones at 45 degree title incidence to the structure. The new polarization converter is optimized and fabricated. Experimental results show that the polarizer takes advantage of both the low insertion loss and the wide 3dB AR bandwidth about 72%.

Single Layer Metasurface Lens Antenna

Daniel Santillán-Haro and Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Daniel Sanchez-Escuderos (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

This paper shows how a set of metallic rings can be used as a planar lens to increase the directivity of a single open waveguide. The goal of this antenna is to obtain a high gain over a wide bandwidth, while maintaining a compact size. In order to obtain a physical insight of the radiating behavior, an analysis of the characteristic modes in the metallic ring of the elementary antenna is performed. An efficient optimization process has been carried out in order to find out the optimum dimensions of the antenna. This study is used to improve the return loss level of a single-layer lens, formed by a central metallic ring surrounded by eight small rings, over a resonant ground circular aperture antenna from 3 to 7 GHz and from 10 to 14 GHz.

Investigation of Large Directivity Bandwidth in Multilayer Resonant Cavity Antennas

Affan Baba (Macquarie University, Australia); Raheel M Hashmi (Macquarie University & IEEE, Australia); Karu Esselle (Macquarie University, Australia)

This paper presents results of an investigation carried out on the large directivity bandwidth of a multi-layer all-dielectric resonant cavity antenna (RCA). This RCA comprises of a multi-layer all-dielectric superstructure, which exhibits a measured broadside directivity of 18.1 dBi with an extremely large 3-dB directivity bandwidth of 51%. Unit cell model of the superstructure is studied by employing superstructure reflection model (SRM) and defect cavity model (DCM). This study reveals that by optimising the frequency separation between two positive phase gradients bands generated by resonant cavities, significant improvement in the directivity bandwidth can be achieved.

Graded Photonic Crystals-based Luneburg Lens

Fabian Gaufillet (Université Paris Sud, France); Eric Akmansoy (Université Paris Sud & Institut d'Electronique Fondamentale, France)

The Luneburg lens is a radially graded index refracting structure that forms geometrical images of two given concentric spheres on each other. This remarkable property of the Luneburg lens makes it very attractive for various domains of frequency and applications, e.g. antennas systems. However, its continuous gradient index is difficult to realize in practice. Herein, we propose the use of graded photonic crystals to attain the radially graded index of the Luneburg lens and show that graded photonic crystals with fitted gradient of filling factor exhibit the properties of the Luneburg lens. We show that, when it focuses an incident parallel beam, it is diffraction limited.

A Planar Equiangular Spiral Antenna Array for the V-/W-Band

Paul Tcheg, Kolawole D. Bello and David Pouhè (Reutlingen University, Germany)

This work presents a spiral antenna array, which can be used in the V- and W-Band. A 4x4-array equipped with Dolph-Chebychev coefficients is investigated in order to address the issues related to the low gain and side lobe level of the radiating structure. The challenges encountered in this achievement are to provide an antenna that is not only good matched but also presents an appreciable effective bandwidth in presence of a dielectric material at the frequency bands of interest. Its radiation properties including the effective bandwidth and the gain are analyzed for the W-Band.

Planar Tri-Band Antenna Element in L/S/C-Bands

Jan Puskely and Alex Yarovoy (Delft University of Technology, The Netherlands); Antoine Roederer (Technical University of Delft, The Netherlands)

A planar tri-band rectangle-rings microstrip antenna design is presented in this paper. The antenna has three equally tuned resonant bands and also maintains consistent radiation patterns in all the operational sub-bands. The

antenna has a single port and its cavity-backed waveguide-like configuration results in minimum mutual coupling levels in antenna array configuration. The antenna element is tuned to operate over the L/S/C radar bands. The antenna is simple and compact structure and measures only 0.25lambda x 0.25lambda at the lowest frequency of operation. Due to its small dimensions, the element is well-suited for application to dense wide-scan phased arrays.

Grating Lobe Suppression in Rotationally Tiled Arrays

Abdullah Alshammary and Stephan Weiss (University of Strathclyde, United Kingdom); Sultan Almorqi (King Abdulaziz City for Science and Technology (KACST), Saudi Arabia)

Uniform placement of array elements limits its maximum frequency due to the formation of grating lobes. While non-uniform element or subarray spacing have significantly lower grating lobes, it reduces aperture efficiency and leads to arrays that are difficult to design and manufacture. We propose a modular asymmetric convex-shaped subarray to construct the array by rotation and translation, filling the aperture without overlaps or gaps. This new approach can achieve lower grating lobes compared to uniform array geometries. It can also lower design, manufacturing and operation costs by offering interoperable subarrays and provide array size flexibility.

Compact Microstrip Branch-Line Coupler with Unequal Power Division

Denis Letavin, Yury E Mitelman and Victor Chechetkin (Ural Federal University, Russia)

a brief overview of modern methods of miniaturization of microstrip devices is presented. A compact design of the directional coupler, which divides the power with the ratio 1:2, is implemented on a substrate with a relative permittivity ε = 4.4 and thickness h = 1 mm. The proposed layout has a considerably smaller size than the traditional design by using lowpass filters having the same phase differences as the replaced segments. The prototype was manufactured and its parameters were measured. The proposed method of miniaturization has allowed reducing the coupler size by 66% in comparison to standard design.

Wideband Illuminator for Radio Telescope Calibration

John Kot (Young & Kot Engineering Research, Australia); Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia)

A wideband illuminator antenna with constant effective aperture is developed for use as a calibration source for a radio telescope. Good performance is obtained over a 6:1 bandwidth

Beamwidth Enhancement of On-Chip Antenna Integrated in Single-chip FMCW Radar Using Periodic Dielectric Lenses

Rabia Syeda (University of Technology Eindhoven & Omniradar Eindhoven, The Netherlands); Bedilu Adela and Martijn van Beurden (Eindhoven University of Technology, The Netherlands); Paul Zeijl (Omniradar, The Netherlands); A. B. (Bart) Smolders (Eindhoven University of Technology, The Netherlands)

We demonstrate a compact design for enhancing the 3dB beamwidth of a 60 GHz single-chip millimeter-wave frequency-modulated continuous wave (FMCW) radar with integrated on-chip antennas. We use thin (λfreespace/5) dielectric periodic lenses on top of the epoxy cover of the single-chip radar to change the effective material properties of the epoxy, which changes the field distribution and hence the radiation pattern and beamwidth of the on-chip antennas. The simulation of our periodic lenses with single-chip radar shows an increased H-plane beamwidth of the on-chip antenna by 60% at the center frequency of 60 GHz. Also, the on-chip antenna radiation efficiency is increased by 20%.

Analysis of Linear Fabry-Perot Antennas Excited by Multiple Sources

Filippo Costa and Davide Bianchi (University of Pisa, Italy); Agostino Monorchio (University of Pisa & CNIT, Italy); Giuliano Manara (University of Pisa, Italy)

The properties of Linear Fabry-Perot antennas excited with multiple sources are analyzed. The antenna can be seen of an array of directive subarrays with overlapped regions. The distance and the level of overlapping should be opportunely controlled in order to avoid unwanted coupling among the ports. The antenna is also analyzed via a simple transverse transmission model approach. The method is based on the superposition of the leaky waves excited by each of the applied sources.

SIW H-plane Horn Antenna Loaded with Double Square Loop Structure

Yang Liu (National Space Science Center & University of Chinese Academy of Sciences, P.R. China); Hongjian Wang (National Space Science Center, P.R. China); Fei Xue and Xingchao Dong (National Space Science Center & University of Chinese Academy of Sciences, P.R. China)

This paper presents two novel designs of SIW H-plane horn antenna which are achieved by adding different double square loops as transition structure. The double square loop and its improvement rotated double square loop are adopted to improve the mismatch between the horn and free space. By optimizing the dimensions of the double square loop structure and rotation angle, the impedance bandwidth can be improved to a large extent. The simulation results of the two designed antennas show that bandwidth can be increased to more than 10% with peak gain between 9 and 12 dBi at center frequency. The performance comparisons of the two antennas are also provided in the paper.

Single-layer Sub-wavelength Reflectarray Elements Based on Multiple-Arm Archimedes Spirals

Fei Xue (National Space Science Center & University of Chinese Academy of Sciences, P.R. China); Hongjian Wang and Guang Liu (National Space Science Center, P.R. China); Xingchao Dong and Yang Liu (National Space Science Center & University of Chinese Academy of Sciences, P.R. China)

Single-layer sub-wavelength reflectarray elements structure for broadband operation are presented. The elements are composed of multiple-arm Archimedes spirals and the lattice periods are a quarter of a wavelength at the center frequency of 13.58GHz. By changing the length of arms, about 500° reflection phase ranges are obtained,

which is a significant improvement compared to conventional subwavelength elements. Besides, the effects of different incident angles on the multiple-arm Archimedes spirals elements are studied and simulation results indicate that the incident angle has little influence on the reflection phase curve of the elements.

Array Pattern Synthesis by Position Shift Method

Chuang Han and Ling Wang (Northwestern Polytechnical University, P.R. China)

A position shift method (PSM) is presented for uniform planar array pattern synthesis in this paper. This method minimizes the sidelobe level (SLL) by searching the best position solution for every sensor and calculating the pattern with position offset factor. The position offset factor will be calculated by the position shift value without changing the physical geometry. Numerical examples show that the proposed method has a lower SLL of -20.40dB for the 100 element planar array with the main beam width maintained, when compared with the other techniques published in the literature.

Design of Multilayer SIW Cavity-Backed Slot Antenna Array

Yang Cai and Yingsong Zhang (PLA University of Science and Technology, P.R. China); Can Ding (University of Technology, Sydney, P.R. China); Zuping Qian (PLA University of Sci. & Tech., P.R. China); Jie Liu (PLA University of Science and Technology, P.R. China)

In this paper, a multilayer substrate integrated waveguide (SIW) cavity-backed slot antenna array with wideband performance is proposed. In order to broaden the operating bandwidth of SIW slot antenna, multilayer cavities with gradually decreased permittivity and expanded aperture sizes are loaded above the slot, which realizes a smooth transition between SIW slot and free space. A wideband feeding network employing slot coupling is designed to excite the array elements. Results indicate the proposed array operates with 28.4% bandwidth ranging from 22.4 to 29.8 GHz. Besides, stable broadside radiation patterns are obtained across the operating band.

Dual-Loop Line Antennas with Wideband Circular Polarization

Kazuhide Hirose and Yuki Nagata (Shibaura Institute of Technology, Japan); Hisamatsu Nakano (Hosei University, Japan)

We investigate two novel microstrip-line antennas. They are composed of symmetric and asymmetric dual-loop radiation elements, respectively. Based on the radiation characteristics of the symmetric (reference) antenna, the asymmetric (present) antenna is designed using the method of moments. It is found that the present antenna radiates a circularly polarized wave with an axial ratio of less than 3 dB in a frequency bandwidth of 10%, which is wider than that of the reference antenna by a factor of three. The theoretical results are validated by experimental ones.

A Grid Array Antenna Composed of Rectangular Loop Cells Printed on a Dielectric Substrate

Toru Kawano (National Defense Academy, Japan); Hisamatsu Nakano (Hosei University, Japan)

The radiation characteristics of a grid array antenna composed of rectangular loop cells printed on a dielectric substrate (PRecL-GAA) are analyzed using the method of moments. It is found that PRecL-GAA radiates a linearly polarized broadside beam. It is also found that the rectangular loop cell contributes to the reduction of the antenna area, not affecting remarkably the HPBW.

Design of 90-degree Transpolarizing Reflected Surfaces

Misagh Khosronejad and Gian Gentili (Politecnico di Milano, Italy)

Transpolarizing surfaces rotate by 90-degree the polarization of the reflected wave with respect to the incident one. A novel transpolarizing or crosspolarizing surface has been proposed. Two different geometries (for broadband and narrowband scenarios) trans-surfaces have been designed and simulated, providing good results for normal incidence.

Bulk Material Dielectric Property Measurement by an Adapted Free-Space UWB Inverse Scattering Method

David Gibbins (Toshiba Research Europe Limited, United Kingdom); Tommy Henriksson and Ian Craddock (University of Bristol, United Kingdom)

This paper presents a system to measure the bulk dielectric properties of a non-metallic target. It is intended as a first step towards a multi-antenna pixel type, imaging system using the same principles. The system, based on the free-space method, comprises two Ultra-Wide Band (UWB) antennas submerged in a tank of lossy background liquid. Data is collected by submerging the Object Under Test (OUT) between the antennas and performing a transmission measurement. The dielectric properties of the OUT are recovered using a UWB inverse scattering algorithm. This employs a 3D Electro-Magnetic (EM) simulation of the system that uses a static conductivity material model. The system is calibrated by means of a measurement without the OUT present. Dielectric properties of a range of materials are recovered to within 10 % of the ground truth. Results suggest that a pixel based imaging system may be viable.

Computational Imaging Using Frequency-Diverse Metasurfaces

Jonah Gollub, Okan Yurduseven, Mohammadreza Imani, Hayrettin Odabasi, Kenneth Trofatter, Michael Boyarsky, Daniel Marks and David Smith (Duke University, USA)

This paper summarizes the recent advances in using frequency-diverse metasurfaces for computational imaging in the microwave and millimeter wave regimes. Frequency-diverse apertures are defined as structures that can generate distinct radiation patterns as a function of frequency. Such waveforms can multiplex a scene information into a set of backscattered measurements, which can be decoded using computational algorithms. In this manner, these apertures can retrieve a scene's reflectivity map using a fast frequency sweep (all-electronic operation), circumventing the requirement for a mechanical scan or active circuit components. We review recent advances in developing these apertures and examine their performance in both simulation and experimental settings. Finally, efforts to build large apertures, which can image at the diffraction limit, are discussed.

Performance of W-band FMCW Doppler Radar FALCON-A for Arctic Cloud Observations

Toshiaki Takano (Chiba University, Japan)

W-band 95GHz Doppler radar named FALCON-A was developed and installed in Arctic station for cloud observations. Spacial resolution in ranging direction is as high as 10m and beam size is 0.18 deg. which corresponds to 15m in the distance of 5km. FALCON-A has regular observations in these three years even in winter seasons. Examples of observation results are shown, in which precise structures and dynamics of cloud interior are revealed.

Active Phased Antenna Arrays Calibration Method Including Edge Effects and Mutual Coupling

Taguhi Chalumyan (LTCI, CNRS, Télécom ParisTech, Université Paris-Saclay, France); Olivier Maas (THALES Air Systems Business Line Surface Radar, France); Xavier Begaud (LTCI, CNRS, Télécom ParisTech, Université Paris-Saclay, France); Bernard Huyart (TelecomParisTech, France)

A new calibration method of active phased array antennas is presented in this paper. This method can be applied to the antenna arrays of various sizes and various radiating element numbers. It takes into account the edge effects and mutual coupling. This method allows avoiding the degradations of the antenna radiation pattern caused by mismatch produced during a scanning and/or a weighting process. HFSS software is used to provide near-field electromagnetic numerical simulations. Matlab is used for far-field calculation from the near-field data; and also for the calculation of the illumination on the antenna surface by back-propagation of far-field data. The calibration process is performed by an optimization process by means of ADS software. An equivalent schematic is built in it in order to obtain desired radiation pattern corresponding to the illumination on the antenna surface. This method is applied to a concrete case in order to demonstrate its efficiency.

Feature Extraction Based on 2D Compressive Sensing for SAR Automatic Target Recognition

Baiyuan Ding and Gongjian Wen (National University of Defense Technology, P.R. China); Fen Ye (Huayin Ordnance test Center of China, P.R. China); Xiaohong Huang and Xiaoliang Yang (National University of Defense Technology, P.R. China)

This paper proposes a new feature extraction method for synthetic aperture radar (SAR) images with application to automatic target recognition (ATR). The original SAR image is first represented by a sparse image containing only a few dominant scattering centers (SCs). According to the theory of 2D compressive sensing (CS), a sparse image can be reconstructed from a low dimensional matrix with little distortion. Therefore, we use 2D random projection to extract features from the sparse image. The proposed method directly works on the 2D images thus avoiding the conversion of 2D matrices to vectors. Based on the extracted feature, the nearest neighbor classifier (NNC) is employed for target recognition. Experiments are conducted on the moving and stationary target acquisition and recognition (MSTAR) to evaluate the validity of the proposed method. Comparison with other methods demonstrates the superiority of the proposed method.

Design of an Equal Division Single-Band Filtering Power Divider Based on Ring Resonator Band-pass Filter

Zafar Bedar Khan and Huiling Zhao (Northwestern Polytechnical University, P.R. China)

In this paper a ring resonator (RR) based band pass filter (BPF) is integrated in the power divider for simultaneous filtering and equal division functions. The proposed co-axial feeding mechanism for the RR ensures the BPF response. Exploiting band-pass characteristics and matching the filter to 70.7 Ω, the RR BPF is integrated in place of the conventional quarter wave transformer in the power divider. In order to ensure good output isolation and return loss (RL), a 50Ω extended transmission line and a resistor is used. Experimental validation was carried out by fabricating the proposed filtering divider. The simulated and measured S-parameter responses were found in good agreement at the fundamental design frequency of 3 GHz and fractional bandwidth of 15%.

Mode-Matching Modeling of Low-Frequency Wireless Telemetry in Deep Oil Fields

Guilherme Rosa (Pontifical Catholic University of Rio de Janeiro, PUC-Rio, Brazil); Jose R Bergmann (PUC-Rio, Brazil); Fernando Teixeira (The Ohio State University, USA)

Wireless telemetry systems from the earth's surface to downhole antennas used in oil and gas exploration generally exploits the annulus between the casing and the tubing as a transmission media. This problem can be efficiently analyzed with a mode-matching technique (MMT), which only require modest computational resource to evaluate the propagation along the entire oil well. Prior MMT results have shown the potential of wireless telemetry systems in deep oil wells using extremely low frequencies. In this paper, we investigate the effects of the presence of a high-loss annulus region and the finite conductivity of metallic pipes on the expected system performance. We show that, for long distances, the fields become mostly confined around the external casing, thus enabling transmission over long well depths despite the high losses in the annular region.

Modeling the Impact of Solar Parks on VHF Aeronautical Communications

Helene Galiègue (ENAC, Université de Toulouse, France); Alexandre Chabory (ENAC, France)

The setting of photovoltaic power stations near aeronautical communication, navigation and surveillance (CNS) devices may cause scattering and multipath effects. For VHF radiocommunications, this may lead to a critical degradation of onboard/ground communications. This paper aims at proposing a fast computation of the impact of such solar parks on communication signals, based on the solar-panels bistatic radar cross section (RCS) and multipath calculation.

Comparisons of Discrete and Continuous Propagators for the Modelling of Low Tropospheric Propagation

Hang Zhou (Ecole National de l'Aviation Civile, France); Alexandre Chabory (ENAC, France); Rémi Douvenot (Ecole National de l'Aviation Civile, France)

For modelling the propagation of electromagnetic waves in the low troposphere, the discrete mixed Fourier method is classically used. It is based on a finite-difference approximation of the ground boundary condition. However, the propagator of the split-step Fourier method is derived from continuous equations. In this paper, we apply the finite-difference approximation to the propagation equation. A discrete operator is derived from these discrete equations. The continuous and discrete propagators are compared. The accuracy of these propagators is numerically analysed

in free space and over an impedance ground. We show that the discrete propagator avoids some numerical instabilities.

Consideration on Incidence and Reflection Characteristics of Hydrated Soil for Landslides Prognostication Systems Using Electromagnetic Waves

Kohsei Kumahara, Kengo Nakajima and Futoshi Kuroki (National Institute of Technology, Kure College, Japan); Masanori Eguchi and Takeshi Yamakawa (Fuzzy Logic Systems Institute, Japan)

Recently, contactless landslides prognostication systems using light wave lasers and ultrasonic waves have been researched and developed, but they suffer from deterioration of detection accuracy due to environment resistance. To overcome such difficulty, electromagnetic waves have been focused on, and a system which can detect water contents in hydrated soil by electromagnetic waves has been investigated in this paper. As the first step, the measurement of the dielectric characteristics of the hydrated soil and the calculation of the incidence and reflection characteristics of the electromagnetic wave in the hydrated soil were performed as a function of the operating frequency. And thus, a possibility to prognosticate landslides was indicated by the reflection performance from the hydrated soil at medium frequency band.

Passively Coded Synthetic Aperture Interferometric Radiometer (CSAIR): Theory and Measurement Results

Ettien Lazare Kpré (Limoges University & XLIM Laboratory, France); Cyril Decroze (XLIM, France)

Based on the synthetic interferometric imaging technique (SAIR), a new microwave radiometer architecture is proposed in this paper to detect thermal noise sources with a passive coded measurement approach so called CSAIR. In this new system, a passive microwave device is used to intrinsically code and multiplex the antenna signals. This allows the reduction of the number of RF chains while keeping the same antenna array configuration needed in a conventional interferometric radiometers. The system principle is described and the signal processing required for the target brightness temperature rendering is also discussed. Simulation and measurement results show the effectiveness and the potential of the proposed system.

Radar Cross Section Measurement of Conformal Antenna Based on Microwave Imaging

Chufeng Hu (Northwestern Polytechnical University, P.R. China); Li Nanjing (Northwest Polytechnic University, P.R. China); Weijun Chen and Guo Shuxia (Northwestern Polytechnical University, P.R. China)

Radar cross section (RCS) of conformal antenna integrated into the aircraft surface cannot be measured by general RCS measurement method. A new method is presented in this paper in order to achieve accurate RCS of conformal antenna. RCS of conformal antenna is obtained by spatial spectral transforming and scaling of two-dimension (2-D) microwave imaging. Empirical results also show the proposed method is effective.

Main Circular Slot Effects on Impedance Matching and Radiation Patterns: Application in UWB Antennas

Mohamed Hayouni (Sup'Com, Tunisia); F. Choubani (SUP'COM, Tunisia); Tan-Hoa Vuong (LAPLACE-INPT, France); J. David (Enseeiht, France)

Parametric studies followed by experimental results of the impedance matching of a compact monopole patch antenna with an embedded half-guided wavelength circular slot, prove that a band-notching/bandwidth enhancement dual role can be achieved by shifting from a semicircular slot to small circular slot respectively by keeping the same inner radius. Moreover, measured radiation patterns in the H-plane are stably omnidirectional at 5.8 and 7.5 GHz. It is shown also that the cross-polarization in the same plane and at the same frequencies are not as low as single monopole due to some strong transverse currents around the small circular symmetric embedded slot. We noticed that there appears to be a close correspondence between the minimum of EΦ and the maximum of Eθ electrical components.

Behavioral Model of Ionospheric Effects in HF Radars

Marie José Abi Akl (Université Pierre et Marie Curie & ONERA, France); Florent Jangal (Onera - The French Aerospace Lab, France); Muriel Darces and Marc Hélier (UPMC Univ Paris 6, France)

The sky and the surface wave radars can be impacted by the instabilities of the ionosphere while they perform continuous surveillance of far off areas. When long-term integration is performed, those instabilities are leading to an increased false alarm rate. This is the typical case when detecting slow targets. In this paper, we will discuss the case of a hybrid mode of detection. Two phenomena can then occur: the fluctuation of the reflection on the ionosphere and the backscattering by irregularities. We will introduce probabilistic models of the ionospheric effects assuming that only the phase path fluctuation has a meaning in the radar point of view. A model has been implemented and applied in the radar processing. The latter is compared to actual data acquired with our high frequency surface wave radar deployed in the south-east of France. The obtained results will be presented during the EuCAP 2017 conference.

Application of Doppler Radar for the Recognition of Hand Gestures Using Optimized Deep Convolutional Neural Networks

Youngwook Kim and Brian Toomajian (California State University, Fresno, USA)

We investigate the optimal structure of deep convolutional neural networks for classifying human hand gestures using Doppler radar. When hand motions are captured by Doppler radar, the unique micro-Doppler signatures can be observed in the spectrogram. If the signature is distinguishable by a classifier, then the hand gesture can be used for controlling electronics and as an input modality for a human-computer interface. To classify signatures in the spectrogram, we propose the use of a deep convolutional neural network (DCNN) as a classifier. DCNN is a powerful classifier that extracts features as well as class boundaries through a training process. We measured seven hand gestures performed in front of Doppler radar while generating spectrograms. To identify an optimal structure, we trained several DCNNs by changing hyperparameters, such as the number of filters. The classification accuracy obtained from the optimal DCNN structure was approximately 87%.

Towards Super-Resolution Impulse-Radar Based on Time-Space Scanning Using Reconfigurable Beamforming and Waveform-Diversity

Mohammad Ojaroudi (Ankara University, Turkey); Hamed Ojaroudi (Antenna Design Group, Microwave Technology Company (MWT), Tehran, Turkey); Mahdi Salimitorkamani (Bio-Electromagnetic Group, Microwave Technology Company (MWT), Tehran, Turkey)

In this paper, we present a novel time-space scanning approach for super-resolution impulse radar application. The proposed structure is designed based on using reconfigurable antenna array and waveform diversity to improve the resolution, contrast and accuracy of target localizing for 1D time domain reflected signal and 2D space visualization of imaging results. For space scanning two array structure including rectangular and round structures are used. In time domain scanning, we present novel waveform diversity approach for high resolution and precision techniques. In order to focus time domain sampling we present here one dimensional time domain reflectometry (TDR) analysis. The proposed modified TDR is very practical as it is based on more realistic signals rather than assuming ideal impulses. Additionally 2D visualization proves that it possible to make a trade of between resolution and contrast improvement. Simulated results show that the proposed methods could be a good candidate for super-resolution application.

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WG_03 Measurement EurAAP WG

WG Meetings & Workshops: Room 313/314

Chairs: Sergiy Pivnenko (Antenna Systems Solutions, Denmark), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Tuesday, March 21, 13:30 - 16:20

TOP

SWS_01: Advances in Commercial Electromagnetic Simulation Tools

WG Meetings & WorkShops: Room 315

Chairs: Marc Rütschlin (CST AG, United Kingdom), Winfried Simon (IMST GmbH, Germany)

Tuesday, March 21, 15:00 - 16:20

TOP

Inv_01 Invited Session 1

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Luis Jofre (Universitat Politecnica de Catalunya, Spain), Andrea Neto (Delft University of Technology, The Netherlands)

15:00 ***Antenna Designs Based on Gap Waveguide Technology***

Eva Rajo-Iglesias (University Carlos III of Madrid, Spain)

Gap waveguide technology is based on the control of wave propagation by using periodic structures. This technology, derived from the metamaterials and artificial surfaces background, has been employed during the last seven years to develop new antenna system components. The main advantage is the compromised low loss characteristic/low cost feature, provided by the possibility of using only metal and the non required electrical contact. Consequently, the technology has a lot of potential to be use in the millimeter wave frequency range. Along these years, classical antenna designs have been revisited using this technology as for instance slot arrays or leaky wave antennas but also other system components such as filters, diplexers or feed networks. A global overview of the technology, the different metasurfaces to be used and mainly the state of the art in terms of antenna designs making use of it will be presented in the talk.

15:40 ***Terahertz Science, Technology, and Applications***

Goutam Chattopadhyay (JPL, USA)

For more than last forty years, terahertz components and instruments have primarily been developed for space science applications in radio astronomy and planetary sciences. However, in recent years, terahertz waves are increasingly being used in commercial applications such as high speed communications, security imaging, autonomous landing and refueling of airplanes, and medicines. In spite of all these fascinating scientific and commercial potential, the terahertz frequency range (loosely defined as 300 GHz < v < 10 THz) still remains one of the least utilized electromagnetic bands because of the unavailability of commercial source and sensor components, and sub-systems. Recent progress in CMOS technology as well as availability of InP HEMT based amplifiers in terahertz frequency band has caught the imagination of researchers for developing terahertz instruments for commercial applications as well. Rapid progress in multiple fronts, such as commercial software for component and device modeling, low-loss waveguide circuits and interconnect technologies, silicon micromachining for highly integrated and compact packaging, and submicron scale lithographic techniques, is making it an exciting time for terahertz engineers and scientists. In this presentation, an overview of the state of the terahertz technology will be presented. The talk will detail the science and other applications that specifically require technology at terahertz frequencies. The challenges of the future generation instruments, detectors, and antennas at these frequencies in

addressing the needs for critical scientific and commercial applications will also be discussed. The research described herein was carried out at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, under contract with National Aeronautics and Space Administration.

Inv_02 Invited Session 2

TOP

Room: Oral Sessions: Auditorium Havane

Chairs: Thomas Kürner (Technische Universität Braunschweig, Germany), Werner Wiesbeck (Karlsruhe Institute of Technology, Germany)

15:00 ***Towards a Channel Model for 5G***

Sana Salous (Durham University, United Kingdom)

Future mobile radio systems are expected to use a variety of techniques and frequencies toward providing high data rates to the user. This has led to a concerted international effort towards characterizing the radio channel in the higher frequency bands particularly in the frequency range of 24-86 GHz following the World Radiocommunications Conference in November 2015 (WRC15). This talk gives an overview of radio propagation measurements in the UK towards achieving a channel model in these frequency bands and the international effort towards achieving such a model.

15:40 ***Human Body Imaging and Remote Vital Monitoring Using UWB Doppler Radar***

Takuya Sakamoto (University of Hyogo & Kyoto University, Japan)

This talk introduces recent developments in the signal processing aspects of ultra-wideband (UWB) radar technology for measuring human bodies. Ultra-wideband radar has various applications, including measuring body shape and action types, and even remotely measuring vital signs such as respiration and heartbeat. This talk covers several advanced signal processing techniques, which are applicable to UWB radar data for retrieving information about the subject. Near-field radar imaging technology is currently used for body scanners at airports intended to detect concealed weapons. Our techniques enable us to generate high-quality radar images quickly, which is crucial for real-time applications. Another technique we have been developing is related to noncontact measurement of vital signs, which could be a breakthrough in the recent trend of health-conscious gadgets. Our signal processing helped us to achieve an unprecedented level of accuracy in the noncontact measurement of instantaneous heartbeat intervals using a multiple-input multiple-output UWB radar system.

WG_03 AMTA Europe Meeting

TOP

WG Meetings & Workshops: Room 313/314

Chairs: Sergiy Pivnenko (Antenna Systems Solutions, Denmark), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Tuesday, March 21, 16:50 - 18:30

Sp_A01 Frequency & Polarization Selective Surfaces

TOP

Space / Regular Session / Antennas

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Andrea Neto (Delft University of Technology, The Netherlands), Min Zhou (TICRA, Denmark)

16:50 ***Broadband Multilayer Polarizer for Low-cost Ka-band Applications***

Darwin Blanco and Ronan Sauleau (University of Rennes 1, France)

In this work we present a broadband multilayer polarizer. It is designed as an add-on device that could be integrated to any linearly-polarized antenna (without affecting its behaviour) to create circular polarization (CP). The achieved axial ratio (AR) is kept below 3 dB within a bandwidth of 14$\%$ ranging from 27.35GHz to 31.35GHz. All results are verified via full-wave simulations over an angular variation of $\pm$60 deg.

17:10 ***Co-Design of Frequency Selective Surface and Antenna Array with Low Angular Dependence***

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

We present the design of a multi-layer frequency selective surface (FSS) composed of subwavelength elements, with large harmonic rejection bandwidth. The FSS design is based on an equivalent circuit model, where the inter-layer interaction is only described with a single transmission line representing the fundamental Floquet wave. To ensure the accuracy of this model, we enforce the FSS period to be comparable to the inter-layer distance. The FSS comprises five metal layers and has an overall height of one sixth of the wavelength at the central frequency of operation. The FSS simulated response exhibits good stability over a wide conical incidence range, up to 45

degrees. The FSS is then combined with a wide-scanning connected array of slots to implement an antenna element for phased array applications, with integrated filtering properties.

17:30 ***Design of Aperiodic Frequency Selective Surfaces for Compact Quasi-Optical Networks***

Min Zhou, Stig Sørensen and Niels Vesterdal (TICRA, Denmark); Raymond Dickie (Queens University Belfast, United Kingdom); Paul Baine and John Montgomery (Queen's University Belfast, United Kingdom); Robert Cahill (Queens University Belfast, United Kingdom); Manju Henry (Rutherford Appleton Laboratory, United Kingdom); Peter Huggard (STFC Rutherford Appleton Laboratory, United Kingdom); Giovanni Toso (European Space Agency, The Netherlands)

The design of an aperiodic frequency selective surface (FSS) for compact quasi-optical networks is presented in this paper. Using a newly developed Physical Optics (PO) method in conjunction with a direct optimisation approach where all elements are simultaneously optimised, an FSS with an aperiodic element layout operating in several discrete bands over the frequency range 23-230 GHz has been designed. The design procedure and a comparison with an existing periodic FSS designed to meet the same specifications are provided. This comparison indicates that enhanced performance can be obtained using an aperiodic FSS compared to a periodic FSS.

17:50 ***Systematic Design of a Class of Wideband Circular Polarizers Using Dispersion Engineering***

Francesco Foglia Manzillo (University of Rennes 1 - IETR, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Ronan Sauleau (University of Rennes 1, France); Anthony Grbic (University of Michigan, Ann Arbor, USA)

A novel topology and a systematic procedure for the design of wideband linear-to-circular polarization converters are presented. The proposed configuration consists of three anisotropic inductive sheets, separated by two dielectric spacers. The dispersion curves for the two polarizations are engineered to achieve a broadband, linear phase response. The design procedure maximizes the differential phase bandwidth. The circuit parameters of the design are derived without any optimization. Fractional bandwidths larger than 48.5%, for incident angles up to 30°, are achieved. A printed circuit board (PCB) realization is discussed in order to numerically validate the proposed approach.

18:10 ***Study of Factors Influencing Performance of Substrate Backed FSS for Millimeter Wave Atmopsheric Remote Sensing***

Jayaprakash Poojali (Indian Institute of Technology Madras, India); Shaumik Ray and Bala Pesala (CSIR CEERI, India); Krishnamoorthy Chitti and Kavitha Arunachalam (Indian Institute of Technology Madras, India)

A Frequency Selective Surface on 175 µm thick quartz with gold trace and unit cell size of 728 µm x 728 µm was proposed in our earlier work for isolating three bands in 50 GHz - 200 GHz range for passive remote sensing. In this work, we present the factors influencing the performance of substrate backed FSS on frequency de-multiplexing. 3D numerical modeling is used to investigate the influence of the thickness of the gold trace and fabrication tolerance on FSS transmission. Scanning electron microscopy (SEM) images confirmed a uniform gold deposition (1.85 µm) across the 35 mm x 35 mm FSS structures with ±2 µm fabrication tolerance on the unit cell dimensions. Continuous wave terahertz measurements of the fabricated samples showed at least 10 dB and 0.5 dB transmission losses in the reflection and transmission bands respectively for TE polarization and varying angle of incidence (0° to 45°).

TOP

CS11 Current Challenges in Low Frequency Antenna System Verification

Space / Convened Session / Measurements

Room: Oral Sessions: Auditorium Havane

Chairs: Benedetta Fiorelli (European Space Agency, The Netherlands), Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy)

16:50 ***RF Verification of RIME Antenna to Be Flown on JUICE Spacecraft***

Uwe Kummer, Christian Imhof and Michael Moll (Airbus DS GmbH, Germany); Dirk Plettemeier (Dresden University of Technology, Germany)

RIME (Radar for Icy Moons Exploration) is a radar sounder for the JUICE (Jupiter ICy moons Explorer) mission. The instrument shall probe the inner structures of the icy crust of the moons Callisto Europa and Ganymede up to a depth of 9 km. For ensuring a sufficient penetration depth the instrument is operated at the frequency range 7.5 - 10.5 MHz. The instrument is equipped with a lambda/2 dipole with decentral feeding. Its RF characteristics are strongly affected by the electromagnetic coupling to the S/C surfaces and also the RF verification is strongly constrained by any coupling to the environment. The presentation outlines the envisaged test approach for verifying impedance, efficiency and selected directions of the antenna pattern first for the isolated antenna and thereafter for an antenna mounted on a S/C mockup.

17:10 ***Deployable VHF Band Log-periodic Dipole Array: Challenges in Verification***

Tao Huang and Vincent Fraux (Oxford Space Systems, United Kingdom)

This paper presents challenges in verifying the design of a space deployable VHF band orthogonal log-periodic dipole array (LPDA). Due to the construction nature of the antenna, operating frequency band, physical dimensions and 1g environment on ground there are a number of challenges in antenna RF measurements and verifications.

These are discussed and presented in this paper.

17:30 ***Experimental Characterization of a Dual-Polarized Direction Finding Array for VHF-UHF Frequency Bands***

Luca Scorrano (Elettronica S.p.A., Italy); Libero Dinoi (Elettronica SpA, Italy)

In this contribution, we present the experimental characterization procedure of a compact DF array for the 70-1300 MHz frequency band, solving critical antenna coupling issues. It comprises four different specialized subarrays enabling both dual-polarization operation and a maximum error in the estimate of the Angle of Arrival (AoA) well below 2° RMS in the most of the frequency and angular interval of interest.

17:50 ***Measurements of Low Gain Antennas at VHF Frequencies for Space-Based AIS Applications***

Andrea Giacomini (Microwave Vision Italy (MVI), Italy); Vincenzo Schirosi (MICROWAVE VISION ITALY, Italy); Francesco Saccardi and Francesca Rossi (Microwave Vision Italy, Italy); Nelson Fonseca and Peter de Maagt (European Space Agency, The Netherlands); Lars Foged (Microwave Vision Italy, Italy)

Measurement of the radiation properties of low gain antennas at VHF frequency is in many cases a challenging task. Measurements performed in shielded anechoic chambers are usually preferred to outdoor ranges because they are not subject to the electromagnetic pollution and less affected by the scattering of the environment. However, different source of errors, such as truncation of the scanning surface and the presence of echoes caused by a poor reflectivity of the anechoic chamber, could affect the measurement results. In such cases, advanced post-processing techniques must be involved. In this paper, the results of two Engineering Models of a low gain VHF space antenna are reported. The first one has been tested in a multi-probe automotive hemispherical range and applying an advanced processing, in order to mitigate the truncation errors. The second has been measured in a spherical multi-probe system with smaller truncated area applying the standard data processing.

18:10 ***UAV-based Antenna Measurements: Scan Strategies***

Fabio Paonessa (IEIIT - CNR, Italy); Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Pietro Bolli (Osservatorio Astrofisico di Arcetri, Italy); Andrea Lingua (Politecnico di Torino, Italy)

In the recent years, the authors developed a system for the characterization of the radiation pattern of VHF and UHF antennas by means of a test-source mounted on a micro Unmanned Aerial Vehicle (UAV). So far, the adopted scan strategies typically consisted of two orthogonal straight paths at constant height from ground to obtain E- or H-plane cuts. In this paper, more complex scan strategies are presented to perform two-dimensional pattern measurements over planar and curved surfaces.

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W_A04 Mm-Wave Antennas for Wireless Networks

Wireless Networks / Regular Session / Antennas

Oral Sessions: Room 341

Chairs: Carlos Del-Río (Public University of Navarra & Antenna Group, Spain), Ingmar Kallfass (University of Stuttgart, Germany)

16:50 ***Experience in Developing LTCC Technologies for mm-Wave Antennas***

Yevhen Yashchyshyn (Warsaw University of Technology & Institute of Radioelectronics, Poland); Paweł R. Bajurko, Przemysław Piasecki, Piotr Włodarczyk, Konrad Godziszewski and Jakub Sobolewski (Warsaw University of Technology, Poland); Beata Synkiewicz and Jan Kulawik (Institute of Electron Technology, Poland)

This paper presents the experience in designing LTCC antennas operated in D-band. A few examined structures are presented and their electrical parameters dependencies on LTCC technology limitations are shown. There are two main points: the first one is related to the quality of multi-layered structures and the second one to the properties of metalization, which has a big influence on electrical parameters of designed structures. Effect of material shrinkage is also investigated. Additionally, possibility of creating air cavities to lower the effective permittivity of substrate material is considered.

17:10 ***A High Gain Steerable Millimeter-Wave Antenna Array for 5G Smartphone Applications***

Manoj Stanley and Yi Huang (University of Liverpool, United Kingdom); Tian Hong Loh (UK, National Physical Laboratory, United Kingdom); Qian Xu (University of Liverpool, United Kingdom); Hanyang Wang (Huawei Technologies, United Kingdom); Hai Zhou (Huawei Technology (UK), United Kingdom)

In this paper, a phased array antenna is designed at millimeter-wave frequency bands for future 5G based smartphone applications. The proposed antenna is a novel open slot-PIFA antenna made on a low-cost FR4 board. The antenna array covers a frequency range of 26-32 GHz with a bandwidth of 6 GHz. The antenna exhibits a very good radiation pattern when integrated with the mobile phone chassis. The 8 - element antenna array exhibits a maximum gain around 13 dBi. The pattern can be steered by varying the phase shift at each antenna element.

17:30 ***Low-Cost Circularly Polarized Spiral Antenna Array for 60 GHz Applications***

Qian Zhu, Kung Bo Ng and Chi Hou Chan (City University of Hong Kong, Hong Kong)

A 4 × 4 circularly polarized antenna array with a substrate integrated waveguide feed network is proposed in this paper. The array is fabricated using low-cost printed-circuit-board and plated-through-hole technologies. The

wideband single element is a modified spiral antenna with unequal arm lengths. The measured -10-dB reflection coefficient and 3.2-dB axial ratio bandwidths are 15.7% and 15%, respectively, while the measured gain at 60 GHz is 18.7 dBic.

17:50 ***Surface-Bulk Micromachined On-Chip Monopole Antenna for 77 GHz Automotive Radar Applications***

Hossam Helaly, Ezzeldin Soliman and Mohamed Serry (The American University in Cairo, Egypt)

This paper presents a micormachined quarterwavelength monopole antenna operating at the millimeterwave band for automotive radar application, specifically a77GHz. The antenna will be realized using surface micromachining on a low resistive thick silicon substrate and fed by coplanar waveguide. Bulk micromachining is used to etch silicon underneath the antenna in order to reduce the Ohmic losses in the substrate. The proposed antenna is analyzed and optimized using CST. The obtained bandwidth, gain, directivity, and efficiency are 40.25%, 3.55 dBi, 5.49 dBi,and 64%, respectively.

18:10 ***Dual-band Slotted Waveguide Antenna Array for Adaptive Mm-wave 5G Networks***

Igor da Costa and Arismar Cerqueira S. Jr. (INATEL, Brazil); Danilo Spadoti (Universidade Federal de Itajubá - UNIFEI, Brazil)

This paper describes the design, simulation and measurement of a dual-band slotted waveguide antenna array for adaptive 5G networks, operating in the millimeter wave frequency range. Its structure is composed by two groups of slots milled onto the opposite faces of a rectangular waveguide, enabling antenna operation over two different frequency bands, namely 28 and 38 GHz. Measured and numerical results, obtained using ANSYS HFSS, demonstrate two bandwidths of approximately 26.36% and 9.78% for 28 GHz and 38 GHz, respectively. The antenna gain varies from 12.6 dBi for the lower frequency band to 15.6dBi for the higher one.

TOP

C_P05 Time-Varying Radio Channels

Cellular Communications / Regular Session / Propagation

Oral Sessions: Room 342A

Chairs: Iñigo Cuiñas (University of Vigo, Spain), Dragan I. Olcan (University of Belgrade, Serbia)

16:50 ***The Excess Attenuation of Propagating Wave in the Presence of Human Crowds***

Jovana Perovic (School of Electrical Engineering University of Belgrade, Serbia); Dragan I. Olcan and Branko Kolundzija (University of Belgrade, Serbia)

We present a formula that can approximate the excess attenuation of electric field of electromagnetic wave propagating in the presence of human crowds. The formula is tested on results obtained from full wave simulations of 2D and 3D stochastic models of human crowds. The electric field is either vertically or horizontally polarized at frequencies 900 MHz and 1800 MHz. We use two stage nonlinear optimizations to find the parameters of the formula.

17:10 ***Channel Modeling for Kiosk Downloading Communication System at 300 GHz***

Danping He and Ke Guan (Beijing Jiaotong University, P.R. China); Bo Ai (Beijing Jiaotong University & State Key Lab of Rail Traffic Control and Safety, P.R. China); Alexander Fricke (Technische Universität Braunschweig, Germany); Ruisi He and Zhangdui Zhong (Beijing Jiaotong University, P.R. China); Akifumi Kasamatsu (National Institute of Imformation and Communications Technology (NICT), Japan); Iwao Hosako (National Institute of Information & Communications Technology, Japan); Thomas Kürner (Technische Universität Braunschweig, Germany)

In the race towards ultra-high-data-rate wireless communication systems, terahertz (THz) band communication is envisioned as a key wireless technology to satisfy this demand and overcome the spectrum scarcity of current wireless systems. As more and more users prefer to accessing digital information with mobile device anytime and anywhere, the close proximity data transfer are needed. In this paper, propagation channel at 300 GHz is studied for Kiosk downloading application. Key parameters of the propagation channel are extracted and modeled based on measurements and calibrated ray tracing simulations. The developed channel model allows for fast generation of channel transfer function. Moreover, the modeling results are evaluated in terms of Rician K-factor and root mean square delay spread. The absolute mean errors of these two metrics are 0.9 dB and 0.07 nanoseconds, respectively. The validated channel model can be used for close proximity communication system design at THz frequencies.

17:30 ***Time-variant Channel Characteristics at 20 GHz Band in Urban Street Canyon Environment***

Ngochao Tran, Tetsuro Imai, Koshiro Kitao and Yukihiko Okumura (NTT DOCOMO, INC., Japan)

This paper presents the time-variant channel characteristics at 20 GHz band for line of sight (LoS) scenario in urban street canyon environment. A measurement campaign was conducted using a channel sounder for 20 GHz band with a 50-MHz-bandwidth. A uniform planar array (UPA) in form of 16-by-16 matrix was also used for the receiver side in order to measure time-variant power delay profiles, azimuth/elevation angle of departures (AoD/EoD). The measured results show that the correlation values of standard deviation (std) of delay spreads (DS), azimuth spread of departure angles (ASD), elevation spread of departure angles (ESD) and transmission distances are 0.78, 0.22, 0.78, respectively. Moreover, the correlation value of std and average of DS is high about 0.98. One the other hand, the correlation value of std and average of ASD, and the correlation value of std and average of ESD are low about 0.04 and 0.55, respectively.

17:50 ***Identifying Radio Waves Direction of Arrival by Doppler Deviation Along Linear Paths At 5.8 GHz***

Iñigo Cuiñas (University of Vigo, Spain); Manuel García Sánchez (Universidade de Vigo, Spain)

This contribution reports the results of a large broad band measurement campaign on the frequency response of radio channels at 5.8 GHz band. Up to five scenarios, in both line of sight and obstructed line of sight, configure the testbed of this work. After gathering data along linear paths, Doppler effect principles allow the estimation of the angle of arrival of any multipath contribution. The analysis of this processing application occupies most of the contribution, which also provides the possibilities and limitations of using such a method to detect the radio sources in a multipath environment.

18:10 ***Experimental Measurements and Channel Modeling for Wireless Communication Networks in Underground Mine Environments***

Alok Ranjan (National Institute Of Technology, Rourkela, India); Prasant Misra (TCS Research & Innovation, India); H Sahu (NIT Rourkela, India)

Compared to rail/road tunnel the characteristics of electromagnetic (EM) wave propagation in underground mine tunnel is significantly different. For reliable operation of wireless communication system in underground mine environment; an understanding of radio signal behavior in such confined space is crucial. This paper discusses the experimental findings carried out in an operational underground mine and further proposed a modified multimode channel model for wireless communication networks in underground mine environments. The proposed channel model is validated with the experimental measurements carried out in both circular and rectangular coal mine tunnels. Based on the proposed channel model, we further analyzed the radio signal behavior considering antenna position and size of the tunnel. Our results are useful to understand the wireless signal propagation characteristics in underground mines, hence may be useful to design reliable and robust communication devices for such high-stress environments.

TOP

CS32 OPTIC BIOEM and other approaches for electropulsation in medicine and biology

Biomedical / Convened Session / Propagation

Oral Sessions: Room 342B

Chairs: Micaela Liberti (ICEmB at "Sapienza" University of Rome, Italy), Caterina Merla (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France)

16:50 ***Microchambers and Devices for Cells Exposure: From the Design to Applications***

Francesca Apollonio (University Sapienza of Rome, Italy); Maura Casciola (Frank Reidy Research Center for Bioelectrics Old Dominion University, USA); Agnese Denzi (IIT, Italy); Micaela Liberti (ICEmB at "Sapienza" University of Rome, Italy); Paolo Marracino (La Sapienza University, Rome, Italy); Caterina Merla (CNRS UMR 8203, Laboratory of Vectorology and Anticancer Therapy, France); Alessandra Paffi (Sapienza University of Rome, Italy)

In the last decades, the advances in the micro and nano-fabrication techniques have led to the development of microdevices that have improved the possibility of analysis at cell level. These devices can be used in different applications: cell detection and identification, manipulation, cell treatments, but in particular they seem extremely promising for nanosecond pulses applications, where the requisite of broadband matching becomes highly demanding. In this paper after a brief review of applicators for nanosecond pulses, a multi step procedure for a good design of microdevices is fixed and an example of microchamber design is given.

17:10 ***Detection of Effects of External Electric Pulses on Properties of Biological Membrane with Electrical and Optical Diagnostics***

Aude Silve (Institute for Pulsed Power and Microwave Technology, Karlsruhe Institute of Technology, Germany); Lars Wegner and Wolfgang Frey (Institute for Pulsed Power and Microwave Technology, KIT, Germany)

Electric pulses can modify properties of cells membrane and make it permeable to molecules that normally are non-permeant. One way to study this effect is therefore to observe transport of molecules across the membrane. However, the outcome of such experiments not only depends on damages induced to the membrane but also on properties of the transported molecules which are investigated and on the transport mechanisms which are involved. Some other approaches, are however available and can provide more straight forward information on the state of a membrane. Electrical diagnostics, such as bioimpedance or patch-clamp, can provide direct information on the modification of the conductance of the cells membrane. Additionally, some optical diagnostics such as measurement of transmembrane voltage using voltage sensitive dyes can also be used to study modification of membrane conductance induced by pulsed electric fields. The benefits and drawbacks of each approaches will be discussed.

17:30 ***Response of Mammalian Cells to Non-thermal Intense Narrowband Pulsed Electric Fields***

Sunao Katsuki (Kumamoto University & Institute of Pulsed Power Science, Japan); Yulan Li, Daiki Miyakawa, Ryo Yamada, Nobuaki Onishi and Soowon Lim (Kumamoto University, Japan)

This paper describes the biological effect of intense pulse electric field from the frequency point of view. 10 μs long sinusoidal electric fields with a frequency range between 0.1 and 100 MHz and field strengths of up to 10 kilovolt per cm were applied to HeLa or HeLa S3 cells, which were subsequently analyzed in terms of the morphology and the Ca2+ response. Our experiment shows that the possibility to physically activate membrane proteins without significant defects of the plasma membrane.

17:50 ***Perfused Organ Model Development and Evaluation for Irreversible Electroporation Investigations***

Suyashree Bhonsle and Mohammad Bonakdar (Virginia Tech, USA); S Nahum Goldberg (Hadassah Medical Centre, Hebrew University, Italy); Rafael Davalos (Virginia Tech, USA); Robert Neal, II (Angiodynamics, USA)

Irreversible electroporation (IRE) is a technique to kill cells by delivering a series of short-duration, high voltage square wave electric pulses into tissue to alter the native cellular transmembrane potential, creating irrecoverable nanoscale defects in the cell membrane. IRE protocols constrain Joule heating below temperatures that cause coagulation of extracellular proteins, and consequently spare critical structures that contraindicate other thermal-based therapies. Tissue-level characterization and optimization of IRE treatment conventionally requires costly and logistically complex in vivo experiments, since affected zones cannot be visualized in expired ex vivo tissue. This has limited IRE protocol evolution. Here, an alternate method using active perfusion of freshly harvested organs with an appropriate viability stain is described, and offers an approach to visualize IRE-affected tissue. The lesions were validated against protocol-matched in vivo trials. This offers an approach to cheaply expedite IRE development, permitting faster protocol and device optimization, ultimately offering better clinical outcomes.

18:10 ***Diversity of Monopolar and Bipolar Nanosecond Pulsed Electric Signals on the Metallo-Enzyme Superoxide Dismutase (SOD), a Modelling Approach***

Elena della Valle (University Sapienza of Rome, Italy); Paolo Marracino (Sapienza University of Rome, France); Olga Pakhomova (Frank Reidy Research Center for Bioelectrics Old Dominion University, USA); Micaela Liberti (ICEmB at "Sapienza" University of Rome, Italy); Francesca Apollonio (University Sapienza of Rome, Italy)

Recent papers showed that when dealing with nanosecond pulsed electric fields (nsPEFs), bipolar pulses proved far less effective at membrane permeabilization and at cell killing than monopolar ones, contrary to what happens in the microsecond range. The mechanism at the basis of such selective response of cells is not fully elucidated. One hypothesis worthwhile to test could be a direct action of nsPEFs on intracellular enzyme reactions. The goal of this study is to investigate possible enzyme response due to the application of nsPEF monopolar and bipolar of intensity of 108 V/m and duration of 100 ns on the superoxide dismutase (SOD,Cu-Zn) enzyme, by means of a molecular dynamics (MD) modelling approach.

TOP

CS47 THz Antennas and Subsystems for High Data Rate Communication Links

High Data-rate Transfer / Convened Session / Antennas

Oral Sessions: Room 343

Chairs: Yi Huang (University of Liverpool, United Kingdom), Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain)

16:50 ***High Data-Rate Communication Link at 240 GHz with On-Chip Antenna-Integrated Transmitter and Receiver Modules in SiGe HBT Technology***

Janusz Grzyb, Pedro Rodriguez Vazquez, Neelanjan Sarmah and Wolfgang Wolfgang Förster (University of Wuppertal, Germany); Bernd Heinemann (IHP, Germany); Ullrich Pfeiffer (University of Wuppertal, Germany)

This paper reports on the development and experimental characterization of a high data-rate communication link at 240GHz with highly-integrated direct-conversion quadrature transmitter and receiver modules implemented in 130nm SiGe HBT technology with ft/fmax of 350/550 GHz. Both modules employ a low-cost chip-on-board packaging scheme with single-chip TX and RX front-end circuits accommodating wideband silicon lens-integrated wire ring on-chip antennas. The key highlights of the developed hardware are its high RF and IF operation bandwidths available from the printed-circuit board-level. With the preliminary wireless transmission tests, a 20Gbps and a 24Gbps transmission speed with an EVM of 24% was demonstrated for BPSK and QPSK modulation schemes at a distance of 90cm with no channel equalization applied. For a 10Gbps BPSK, an error-free communication link could be established.

17:10 ***Design of Electronic Subsystems for a 300 GHz Wireless Communication System***

Jose M. Perez and Iñigo Ederra (Universidad Publica de Navarra, Spain); Ramon Gonzalo (Public University of Navarra, Spain)

Recently, there has been an increasing interest in the THz gap due to the attractive applications that can be developed. Among these applications, high data rates communication system links get an important relevance due to the potential high bandwidth that can be obtained. In this paper, a frequency tripler and a fourth harmonic mixer for a wireless communication link at 300 GHz has been designed. Conversion Loss (CL) of the tripler is around 15 dB for 65 GHz bandwidth in which the best value is 12 dB for 318 GHz. For the fourth harmonic mixer, the CL obtained is around 18 dB within 41 GHz bandwidth. The best value is 10.2 dB for 301 GHz.

17:30 ***High-Power Terahertz Emitter for a Communication Link: The Chessboard Array***

Alejandro Rivera-Lavado, Kerlos Atia-Abdalmalak and Gabriel Santamaria-Botello (Universidad Carlos III de Madrid, Spain); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Guillermo Carpintero and Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain); Ivan Camara-Mayorga (Max Planck Institute fur Radioastronomy, Germany); Luis-Enrique Garcia-Muñoz (University Carlos III of Madrid, Spain)

This manuscript proposes a high-power terahertz source that consists on a large amount of coherently driven photomixing THz sources. Each element is placed in the gap of a bow tie antenna. The resulting array defines a

chessboard-like layout which maximize the density of devices. This novel concept is validated through full-wave simulations. Experimental considerations are also provided for a prototype manufactured for the 1550 nm window. Measured power level will be shown at the conference.

17:50 ***Design of Graphene-based Plasmonic Nano-antenna Arrays in the Presence of Mutual Coupling***

Luke Zakrajsek and Erik Einarsson (University at Buffalo, USA); Ngwe Thawdar (AFRL); Michael Michael Medley (AFRL, USA); Josep M Jornet (University at Buffalo, USA)

Graphene-based plasmonic nano-antennas are envisioned as the enabling component for communication in the Terahertz (THz) band (0.1-10THz). Despite their efficiency and due to their size, the total radiation power is expectedly very low. To overcome this limitation, plasmonic nano-antenna arrays are proposed. In this paper, by using analytical models backed by numerical simulations, the performance of such arrays are analyzed while taking into account mutual coupling effects. It is shown that a nano-array can provide significant gain in relation to only a single nano-antenna while still occupying a compact footprint. The results in this paper serve as a building block towards future THz communication systems.

18:10 ***A THz Impulse Communications System***

Elliott Brown (Wright State University, USA)

THz impulse communications is a new system concept based on an imaging radar that we have been developing for biomedical imaging applications the past ten years. Its hybrid architecture combines the high-peak-power and spread-spectrum of photoconductive-switch transmitters with the high-responsivity and broad-bandwidth (RF and video) of Schottky-rectifier receivers. The data is impressed by simple on-off keying of the transmitter utilizing the very stable repetition frequency of the fiber mode-locked laser (MLL) that drives the PC switch.

TOP

CS18 Glide Symmetry Surfaces for mm and Sub-mm Lens Antennas

Future Applications / Convened Session / Antennas

Oral Sessions: Room 351

Chairs: Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden), Krishnaswamy Sankaran (ETH Zurich & IIT Bombay, Switzerland)

16:50 ***Glide-Symmetric Metasurfaces: Theory, Simulation and Practice***

Oscar Quevedo-Teruel, Mahsa Ebrahimpouri and Fatemeh Ghasemifard (KTH Royal Institute of Technology, Sweden); Malcolm Ng Mou Kehn (National Chiao Tung University, Taiwan); Rhiannon C Mitchell-Thomas (University of Exeter, United Kingdom); Anthony Grbic (University of Michigan, Ann Arbor, USA); Zvonimir Sipus (University of Zagreb, Croatia); Eva Rajo-Iglesias (University Carlos III of Madrid, Spain); Guido Valerio (Sorbonne Universités UPMC, France)

In this paper, we summarize the recent results in electromagnetic glide-symmetric structures. A periodic structure is glide-symmetric when its lattice is created by a periodic mirroring and translation. These structures were of the interest to the microwave and antenna community during the '60s for one-dimensional periodicities. Recently, research on metasurfaces has revived the study of glide-symmetric structures due to their exceptional qualities in terms of low dispersion and rejected bands. Two-dimensional glide-symmetric metasurfaces find applications in lens antennas and gap waveguide technology.

17:10 ***Floquet-Mode Analysis of Glide-Symmetric Metasurfaces***

Zvonimir Sipus (University of Zagreb, Croatia); Guido Valerio (Sorbonne Universités UPMC, France); Anthony Grbic (University of Michigan, Ann Arbor, USA)

In this paper, the analysis method for analyzing metasurface parallel-plate waveguides with glide symmetry is presented. The analysis method is based on Floquet-mode representation of the EM field inside the parallel-plate, and on matching it with the EM field at the waveguide opening. By this, a characteristic equation for the propagation constant of the waveguide mode is derived. The analysis method is tested by comparing the calculated propagation constant with the results obtained by a general electromagnetic solver.

17:30 ***High Index Metasurfaces for Graded Lenses Using Glide Symmetry***

Rhiannon C Mitchell-Thomas, John Sambles and Alastair Hibbins (University of Exeter, United Kingdom)

A metasurface which has glide symmetry in two orthogonal directions is given here as the building block for the design of surface wave lenses. This metasurface is shown to have reduced frequency dispersion when compared to a similar structure with reflection symmetry only. This work has the potential to create graded index lenses, with a high mode-index contrast, for use in surface wave antenna applications.

17:50 ***Design of High Directivity Slot Arrays in the Millimeter-Wave Range Based on Groove Gap Waveguide Implemented with a Glide-Symmetric Holey Structure***

Eva Rajo-Iglesias (University Carlos III of Madrid, Spain); Astrid Algaba Brazález (Ericsson Research, Ericsson AB, Sweden)

The use of gap waveguide technology is increasing continuously. In this work we present the first studies on the use of a new type of periodic structure to create the desired stop band and its application to design array antennas. The new unit cell belongs to the known as glide-symmetric structures and has a very simplified manufacturing. The latter is due to the larger periodicity of the structure when compared to the classical pins but also because manufacturing holes is always easier than making pins.

18:10 ***All-metal Ku-band Luneburg Lens Antenna Based on Variable Parallel Plate Spacing Fakir Bed of Nails***

Cheikh Diallo (IETR & Université de Rennes 1, France); Etienne Girard (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France); Ronan Sauleau (University of Rennes 1, France)

This paper presents an all-metal parallel plate waveguide (PPW) Luneburg lens designed using an array of subwavelength Fakir bed of nails unit-cells. Variation of the metal post height and PPW-spacing modulates the effective refractive index. The lens operates in the Ku-band of frequencies, with more than 40\% bandwidth, in a quasi-TEM mode. Broadband and low loss, with high directivity and wide field-of-view, this antenna could be an excellent candidate as a lens-like beamformer for multiple beams satellite communication applications.

TOP

R_P01 Radar Imaging

Radars / Regular Session / Propagation

Oral Sessions: Room 352A

Chairs: Carey Rappaport (Northeastern University, USA), Okan Yurduseven (Duke University, USA)

16:50 ***A Null Steering Method for Detecting Buried Objects with Forward-Looking GPR***

Yukinori Fuse and Masoud Rostami (Northeastern University, USA); Borja Gonzalez-Valdes (University of Vigo, Spain); Carey Rappaport (Northeastern University, USA)

A null steering method for Forward-Looking Ground Penetrating Radar (FLGPR) is presented. The radar consists of two arrays (one at L-band and one at X-band) of wideband horns that form synthetic apertures at the vehicle advanced. The null steering method is applied to the SAR vertical view (intensity vs. range and height) image to compensate for the lack of vertical image resolution and help determine if a scatterer is above the ground or buried. First, a target point is selected in the original SAR image, then a null for point spread function (PSF) is calculated for that point. The null PSF is applied to field data to indicate the position of the scatterer. This method is tested with a full-wave scattered field synthetically generated by FDFD, and with field measurement data.

17:10 ***Optimization of Frequency-Diverse Antennas for Computational Imaging at Microwave Frequencies***

Okan Yurduseven and Jonah Gollub (Duke University, USA); Thomas Fromenteze (Duke University, France); Daniel Marks and David Smith (Duke University, USA)

Frequency-diverse imaging is an all-electronic method, capable of sampling the scene to be imaged without the need for a mechanical scan or active circuit components. In order to optimize the imaging characteristics, such as imaging resolution and fidelity of the reconstructed images, the antennas used within this scheme need to be optimized. It is demonstrated that using a Mills-Cross iris distribution, superior sampling of the Fourier components (wide support extent and minimum sampling redundancy) can be achieved. Using the optimized antennas, an experimental imaging system is built, reconstructing a good quality image of a cross-shaped target in less than 0.1 seconds.

17:30 ***Single-Frequency Near-Field MIMO Imaging***

Thomas Fromenteze (Duke University, France); Michael Boyarsky, Jonah Gollub and Timothy Sleasman (Duke University, USA); Mohammadreza Imani (University of Michigan, USA); David Smith (Duke University, USA)

A near-field radar imaging technique is presented based on single-frequency measurements from a multiple-input multiple-output (MIMO) array. Such arrays are able to fully sample the k-space of a region of interest. Advantageously, both range and cross-range information can be reconstructed, in contrast to conventional single-input multiple-output systems which require wideband frequency illumination. A theory of single frequency MIMO imaging is developed and studied through numerical modeling and experimental validation.

17:50 ***A New Regularization Method for Radar Cross Section Imaging***

Thomas Benoudiba-Campanini (Université de Bordeaux & CEA CESTA & IMS Bordeaux, France); Pierre Minvielle (CEA CESTA, France); Pierre Massaloux (CESTA, France); Jean-François Giovannelli (IMS, UMR CNRS 52 18, Université Bordeaux 1, France)

RCS analysis is the study of the scattering behavior of an object. The objective is to determine the main scatterers from measurements of the backscattered electric field. It is generally achieved by Radar Cross Section imaging. This leads to an ill-posed inverse problem because the system to solve is underdetermined. It is then necessary to regularize the problem by adding prior information. In this paper, a new constrained and sparse regularization method for Radar Cross Section imaging is proposed. It is based on the finite spatial electromagnetic extension of the target and its expected small number of scatterers. A least squares criterion with a L1 penalty and support constraints is developed. It is minimized by an efficient algorithm resting on an ADMM. The application to real scattered measurements is very promising, with a limited computation time. Compared to the conventional approach, the image resolution is drastically increased.

18:10 ***Electromagnetic Imaging of Wave Impenetrable Objects***

Xiuzhu Ye (Beihang University, P.R. China)

This paper proposed a volume pixel subspace based optimization method (SOM), to solve the electromagnetic imaging problem of the wave impenetrable objects/perfect electric conductor (PEC). In this proposed method, the PEC objects are approximated by highly lossy dielectric scatterers with pure imaginary permittivity and thus volume pixel SOM is successfully employed. There is no prior information such as the number and locations of scatterers required in the inversion. Synthetic data as well as experimental data are both employed to test the

validity of the method. The surface pixel SOM is also used to compare with this volume pixel SOM, showing that the nonlinearity of volume pixel SOM is reduced greatly and is much faster than the surface pixel SOM.

CS37 Propagation in Aeronautics

TOP

Localization & Connected Objects / Convened Session / Propagation

Oral Sessions: Room 352B

Chairs: Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany), Fernando Pérez-Fontán (University of Vigo, Spain)

16:50 ***L- And C-Band Airframe Shadowing Measurements and Statistics for a Medium-Sized Aircraft***

David W Matolak (University of South Carolina, USA); Ruoyu Sun (National Institute of Standards and Technology, USA); Hosseinali Jamal and William Rayess (University of South Carolina, USA)

Airspaces worldwide are becoming more heavily used. This includes the use of unmanned aircraft systems, which is rapidly growing. In order to ensure reliable communication for aircraft, the air-ground channel must be accurately characterized. A significant channel impairment that has not been thoroughly studied is airframe shadowing—obstruction of the line-of-sight signal by the aircraft itself. In this paper, we report on measured results for this shadowing phenomenon in two frequency bands, for a medium-sized aircraft. We present results for two example shadowing events in terms of shadowing depth and duration, and provide distributions of shadowing depth and duration. We show that for both bands, airframe shadowing can be more than 30 dB, and can last for tens of seconds.

17:10 ***Modeling the Air-Ground Multipath Channel***

Nicolas Schneckenburger, Thomas Jost and Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany); Hosseinali Jamal and David W Matolak (University of South Carolina, USA); Ruoyu Sun (National Institute of Standards and Technology, USA)

The paper proposes a geometrical-statistical modeling approach for the air-ground channel for \ac{CNS} systems in the L-band frequency range. We sketch the architecture of the model with its six elements and show how their parameters can be derived from measurement data. Preliminary results obtained from a relatively small set of measurement data reveal that the proposed modeling approach is well suited to capture the time variant behavior of the channel. However, a considerably more extensive evaluation of the measurement data will be necessary to finalize the parameter settings of the proposed channel model.

17:30 ***Addressing Scattering From Tree Canopies by PO and MST for Aeronautical and Inland Waterways Scenarios***

Milan Kvicera (Czech Technical University in Prague, Czech Republic); Fernando Pérez-Fontán (University of Vigo, Spain); Jonathan Israel (ONERA - The French Aerospace Lab, France); Pavel Pechac (Czech Technical University in Prague, Czech Republic)

A new model addressing scattering from tree canopies is presented in this paper. The model is based on a combination of physical optics and the multiple scattering theory (MST) and provides significant improvements when compared to the case when only MST is utilized, especially the correct near field calculations. The model is validated against MST at 2 GHz and 10 GHz for the case of an artificial scenario and also against a set of experimental data obtained at 2 GHz for a single isolated tree.

17:50 ***Low Altitude UAV Propagation Channel Modelling***

Xuesong Cai (Tongji Unversity, P.R. China); Ana Gonzalez-Plaza and David Alonso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Lei Zhang (Universidad Politecnica de Madrid, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Antonio Perez Yuste (Technical University of Madrid, Spain); Xuefeng Yin (Tongji University, P.R. China)

The Unmanned Aerial Vehicle (UAV) is going to play an important role in fifth generation communication systems for establishing seamless coverage in various scenarios due to its low- cost and flexibility. Understanding the UAV wireless channels is the basis for its application. In this paper, a recently conducted measurement campaign for the UAV wireless propagation channel in a suburban scenario in Madrid is introduced. Based on the Universal Software-defined Radio Peripheral (USRP) equipment, narrowband measurements at frequency of 5.76 GHz and broad- band measurements at frequency of 1.817 GHz are performed. The path loss, K-factor, power delay profiles (PDPs), multipath components (MPCs) and root-mean-square (RMS) delay spreads (DSs) are presented.

18:10 ***Using Airborne Measurements to Model the Satellite-to-Aircraft Channel Model at L-Band***

Thomas Jost (German Aerospace Center (DLR), Germany); Tanja Pelzmann (École Polytechnique de Montréal, Canada); Martin Schwinzerl (Joanneum Research, Austria); Michael Walter (German Aerospace Center (DLR), Germany); Michael Schönhuber (Joanneum Research, Austria); Nicolas Floury (ESA, The Netherlands)

Radio wave propagation from a satellite based emitter to an airborne located receiver is of interest for applications like passenger internet access during a flight, air traffic management or positioning by global navigation satellite

systems (GNSSs). Especially for the last two applications that are related to safety-of-life functionality, accurate channel models for software based system testing are essential. Current state-of-the art channel models for the satellite-to-aircraft case lack of accuracy in terms of modeling all propagation impairments. In this contribution, we describe an airborne experiment using Global Positioning System (GPS) satellite emitted signals to characterize the wave propagation channel from a satellite to an airborne platform. First results on ground reflected multipath are provided.

CS43 Signal Processing Techniques to Improve Antenna Characterization Procedures (AMTA/EurAAP)

TOP

Methods & Tools / Convened Session / Measurements
Oral Sessions: Room 353
Chairs: Stuart Gregson (NSI-MI & Queen Mary, University of London, USA), Laurent Le Coq (University of Rennes 1 & IETR, France)

16:50 ***GPU-based Computational Acceleration of Phaseless Algorithms for Antenna Characterization***

Juan Carlos Fernandez Gonzalez (Universidad de Oviedo, Spain); Miguel Lopez Portugues (Universidad de Oviedo - Area de Teoria de la Señal, Spain); Yuri Álvarez, Jesús Alberto López-Fernández and Fernando Las-Heras (Universidad de Oviedo, Spain)

In the field of antenna diagnosis and characterization, the Sources Reconstruction Method (SRM) has been proved to be a powerful tool enabling the use of arbitrary-geometry measurement and reconstruction surfaces. The SRM has been extended for phaseless antenna characterization using two or more acquisition surfaces, as a simpler (but slower) alternative to holographic techniques. One of the main drawbacks of phase retrieval using multiple surfaces is the need of solving a set of nonlinear equations relating the measured amplitude with a set of equivalent currents using iterative, time-consuming methods. This contribution aims to improve the applicability of this methodology by reducing the time cost of the iterative procedure by means of Graphics Processing Units (GPU). Speed-up rates ranging from 50 to 90 times compared with sequential CPU (Central Processing Unit)-only implementation have been achieved.

17:10 ***A Novel Approach for Circular Array Testing***

Daniele Pinchera and Marco Donald Migliore (University of Cassino, Italy)

In this contribution the use of circular Plane Wave Generator (PWG) for testing large circular arrays is discussed. In particular, it is shown that the synthesis method proposed in the present paper allows the use of a lower number of radiating elements compared with previous PWG approaches.

17:30 ***Using Partial Information to Predict the Radiation Pattern of an Antenna in Complex Scenarios***

Marco Righero (Istituto Superiore Mario Boella, Italy); Giorgio Giordanengo (Istituto Superiore Mario Boella & Politecnico di Torino, Italy); Matteo Alessandro Francavilla (Istituto Superiore Mario Boella, Italy); Francesca Vipiana and Giuseppe Vecchi (Politecnico di Torino, Italy)

A method to characterize an antenna radiation pattern in complex scenarios starting from partial information is described and some preliminary results are shown. In a controlled environment with synthetic data, the method is able to reconstruct the target field with a downsampling of 15 times with respect to Nyquist criterion with negligible errors

17:50 ***Examination of the Effectiveness of Far-field Mathematical Absorber Reflection Suppression in a CATR Through Computational Electromagnetic Simulation***

Stuart Gregson (NSI-MI & Queen Mary, University of London, USA); Clive Parini (QMUL, United Kingdom); Allen Newell and Greg Hindman (Nearfield Systems Inc., USA)

For a little over a decade, a measurement and post-processing technique named Mathematical Absorber Reflection Suppression (MARS) has been used successfully to identify and then suppress range multi-path effects in spherical, cylindrical & planar near-field antenna measurement systems and far-field and compact antenna test ranges (CATR). Much of this early work concentrated on verification by empirical testing however some corroboration was obtained with the use of computational electromagnetic simulations. The recent development of a highly accurate computational electromagnetic simulation tool that permits the simulation of "measured" far-field pattern data as obtained from using CATR has for the first time permitted the careful verification of the far-field MARS technique for a given AUT and CATR combination. For the first time, this paper presents simulated "measured" far-field pattern data in the presence of a large scatterer and then verifies the successful extraction of the scattering artefacts using standard FF-MARS processing.

18:10 ***Spherical Near-Field Far-Field Transformation with Infinite Ground Plane At Arbitrary Height z***

Rasmus Cornelius and Dirk Heberling (RWTH Aachen University, Germany); Dieter Pototzki (Antenna Technology Center Europe & ATC GmbH, Germany)

In measurement scenarios with ground planes the boundary condition has to be included appropriately in the near-field to far-field transformation. For spherical near-field antenna measurements, techniques exist to include a ground plane in the xy-plane z = 0 m. In this paper we will describe a transformation procedure including a translation of the transformation origin, so that the ground plane can be at any height z to overcome that limitation of existing techniques. The procedure is demonstrated by a simulation and measurement example.

CS46 The Alphasat Aldo Paraboni Scientific Experiment: Results and Developments after 3 Years of Operations

TOP

Space / Convened Session / Propagation
Oral Sessions: Room 362/363
Chairs: Lorenzo Luini (Politecnico di Milano, Italy), Antonio Martellucci (European Space Agency, The Netherlands)

16:50 ***The ASI and ESA Activities for the Alphasat Aldo Paraboni COMEX and SCIEX Activities at Ka and Q/V Bands***

Antonio Martellucci and Juan J. Rivera Castro (European Space Agency, The Netherlands); Philippe Sivac (ESA ESTEC, Germany); Giuseppe Codispoti (Italian Space Agency, Italy); Edoardo Benzi (ESA ESTEC, The Netherlands)

This paper presents an overview of the activities performed by the Agency in the framework of the Alphasat Aldo Paraboni scientific experiment at Ka and Q band. In particular it addresses the technological developments for the equipment of the propagation campaign, the execution of mission related activities, the execution of propagation campaigns, the international cooperation with the group of propagation experimenters and the planning for future activities. The paper is intended to provide the general European background of experimental results published on scientific publications and conferences.

17:10 ***Large Scale Assessment of Ka/Q Band Atmospheric Channel Across Europe with ALPHASAT TDP5:The Augmented Network***

Spiros Ventouras (STFC Rutherford Appleton Laboratory, United Kingdom); Richard Reeves (Science & Technology Facilities Council & RAL Space, United Kingdom); Emal Rumi (STFC Rutherford Appleton Laboratory, United Kingdom); Fernando Pérez-Fontán, Fernando Machado and Vicente Pastoriza (University of Vigo, Spain); Armando Rocha and Susana Mota (University of Aveiro & Institute of Telecommunications, Portugal); Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal); Athanasios D. Panagopoulos, Apostolos Z. Papafragkakis and Charilaos Kourogiorgas (National Technical University of Athens, Greece); Ondrej Fiser (Institute of Atmospheric Physics & Fac. of Electrical Engineering and Informatics/Uni of Pardubice, Czech Republic); Viktor Pek (Institute of Atmospheric Physics CAS, Czech Republic); Petr Pesice (Institute of Atmospheric Physics Prague, Czech Republic); Martin Grabner (Czech Metrology Institute, Czech Republic); Andrej Vilhar and Arsim Kelmendi (Jozef Stefan Institute, Slovenia); Andrej Hrovat (Jožef Stefan Institute, Slovenia); Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium); Alberto Graziani (Université Catholique de Louvain, Belgium); Laurent Quibus (UCL, Belgium); George Goussetis (Heriot-Watt University, United Kingdom)

The upcoming migration of satellite services to higher bands, namely the Ka- and Q-bands offers many advantages in terms of bandwidth, data rates and system capacity. However, it poses challenges as propagation effects introduced by the various atmospheric phenomena are particularly pronounced in these bands and can become a serious constraint in terms of system reliability and performance. This paper outlines the goals, organization and some first results of an ongoing large propagation campaign consortium formed across Europe under the supervision of the European Space Agency; the campaign, shall ultimately assist in the validation and development of channel models targeting these-bands. Finally, the consideration of diverse climatic conditions and elevation angles along with the evaluation of the frequency and spatio-temporal effects, shall support the development of Fading and Mitigation Techniques and their assessment using real data.

17:30 ***The Joanneum Research SatCom Ka and Q Band Campaigns in Europe and Malaysia***

Félix Cuervo (Joanneum Research, Austria); Hong Yin Lam (Universiti Tun Hussein Onn Malaysia, Malaysia); Jafri Din (Wireless Communication Centre, Universiti Teknologi Malaysia); Juan J. Rivera Castro (European Space Agency, The Netherlands); Michael Schmidt (Researcher, Austria); Michael Schönhuber (Joanneum Research, Austria)

In satellite communications, the demand for capacity increase is met by the use of higher frequency bands, which however are severely impaired by atmospheric phenomena (rain, cloud and gaseous attenuation, scintillation). In order to study propagation effects for future satellite communication frequencies both in temperate and tropical climates, JOANNEUM RESEARCH carries out two long-term propagation measurement campaigns, one in Europe with the Alphasat Aldo Paraboni payload at Ka-band (19.7 GHz) and Q-band (39.4 GHz), and another one in two sites in the tropical region of peninsular Malaysia, where the climatic differences affect the propagation channel characteristics. This paper reports on both campaigns and presents the statistical analysis of experimental results and their comparison with the existing ITU-R propagation models.

17:50 ***Results of a Ka Band Campaign for the Characterisation of Propagation Conditions for SatCom Systems at High Latitudes***

Terje Tjelta (Telenor, Norway); Martin Rytir and Lars Erling Bråten (Norwegian Defence Research Establishment (FFI), Norway); Per Arne Grotthing (Telenor Satellite, Norway); Michael Cheffena (Gjøvik University College, Norway); Jan Erik Håkegård (SINTEF, Norway)

Satellite services in the High North are utilized extensively for both communication purposes and for earth and climate observations. This paper presents results of two year measurements at 20 GHz and co-sited meteorological

data. The results suggest that with 7-8 dB margin, services can be provided with 99 % availability for systems with elevation angles as low as 3.2 deg. Measured attenuation distributions support International Telecommunication Union prediction methods within 3 to 4 dB for 99.99 % of the time. However, scintillation and multipath are not well predicted at the lowest elevation angle.

18:10 ***Measurement and Modelling of Tropospheric Scintillation in Ka/Q Band***
Danielle Vanhoenacker-Janvier (Université catholique de Louvain, Belgium); Laurent Quibus (UCL, Belgium); Martin Rytir (Norwegian Defence Research Establishment (FFI), Norway); Terje Tjelta (Telenor, Norway)
The purpose of this paper is to present the use of Numerical Weather Forecast software to generate 4D-meteorological parameters for the characterization and simulation of tropospheric scintillation. The simulator has been tested against scintillation measurements at 30 degree elevation and is used for a further analysis of the turbulence characteristics on a low elevation earth-space link

IWS_03: New Over-the-Air Measurement Methods and Design Considerations for Millimeter Wave Antenna Arrays

TOP

WG Meetings & WorkShops: Room 315
Chairs: Riccardo Giacometti (Keysight Technologies, France), Pekka Kyösti (Keysight Technologies & University of Oulu, Finland), Moray Rumney (KeysightTechnologies, United Kingdom)

Wednesday, March 22

Wednesday, March 22, 08:40 - 12:30

CS17 From Pioneering Antenna Contributions to Industrial Applications

TOP

Space / Convened Session / Antennas
Room: Oral Sessions: Auditorium Havane
Chairs: Eric Amyotte (MDA, Canada), Giovanni Toso (European Space Agency, The Netherlands)

08:40 ***Antennas at MDA: Innovation Through Cross-Pollination***
Eric Amyotte and Marc-André Godin (MDA, Canada)
This paper presents how several technological advancements in communication satellite antennas have been transferred to other applications and synergistically combined to enable significant reductions in the cost per billable bit of throughput.

09:00 ***Active Antenna Developments for Telecom Applications at Thales Alenia Space***
Eric Vourch (Thales Alenia Space France, France); Christian Féat, Philippe Lepeltier and Fabien Delepaux (Thales Alenia Space, France); Michel Soudet (THALES ALENIA SPACE, France); Jean-Christophe Lafond (Thales Alenia Space, France)
This paper deals with the Active Antenna recent developments in Thales Alenia Space. Current heritage for telecommunication applications is described, focusing on L and S band constellations, reconfigurability in Ku/Ka bands and anti-jamming from X to Ka bands. In addition, key drivers in the active antenna design will be discussed; they will include architecture considerations, efficient software toolings and test techniques to provide a product the closest to the system need. Finally, the recent development of key building blocks are presented and compared to payload market trends for future customer requirements from L to Ka bands.

09:20 ***Advanced Optimization Techniques for Design, Prototyping and Industrialization of Satellite Antennas: a Space Engineering Perspective***
Piero Gabellini (Space Engineering S.p.a., Italy); Gianfranco Ruggerini, Luciano D' Agristina and Domenico Di Lanzo (Space Engineering S.p.A., Italy)
The paper deals with the extensive use of optimization techniques at Space Engineering during the several phases of development of antenna sub-systems for satellite applications

09:40 ***Satellite Antenna Capabilities Pioneered at Lockheed Martin Space Systems Company***
Erik Lier (Lockheed Martin Corporation, USA); Julie Huffman (Lockheed Martin, USA); William N Kefauver (Lockheed Martin & University of Colorado, Boulder, USA); Frank Butscher (Lockheed Martin, USA)
Lockheed Martin Space Systems Company has pioneered advanced antenna solutions over several decades and built a wider range of payload solutions than any other company in the industry. This paper presents a few antenna technologies which has been successfully developed and flown over the years.

10:00 ***From Modest Multi Beam Towards VHTS: Feed System Evolution at AIRBUS DS GmbH***
Christian Hartwanger (Airbus DS GmbH, Germany); Michael Schneider (Airbus, Germany)

To illuminate a certain footprint on Earth, a corresponding aperture distribution of the antenna in space needs to be generated. There are various possibilities to generate this distribution. A general classification is for example the distinction between direct radiation and radiation via reflecting apertures. The way how the illumination is realised is directly linked to the complexity of the required feed system. Looking back, one can observe a change from small simple feed systems towards large complicated multifeed arrays, back to simple feeds again. Nowadays we again see the request for large feed systems and complex multifeed arrays. In this paper, we present a short history on antenna systems and the corresponding feed systems over the recent decades. An insight on current feed systems and future products is given.

10:20 Coffee Break

10:50 *Antennas for Observation, Exploration and Navigation in ThalesAleniaSpace-Italia: Past and Present Challenges*

Roberto Mizzoni and Pasquale Capece (Thales Alenia Space Italia, Italy); Salvatore Contu (Thales Alenia Space, Italy); Alberto Meschini (ThalesAleniaSpace-Italia, Italy); Giovanni Rosati (Thales Alenia Space - Italia, Italy)

The paper provides an overview of the most significant space antenna products and technologies for Observation, Exploration and Navigation (OEN) developed by ThalesAleniaSpace-Italia (TAS-I) over more than 30 years. These antennas provided a determinant contribution to the scientific community in understanding earth environment and solar planets. An outline of today key developments is also presented.

11:10 *Heritage of Mitsubishi's Phased Array Antennas Development for Mobile Satellite Communications*

Hiroyuki Sato and Hiroaki Miyashita (Mitsubishi Electric Corporation, Japan)

This paper introduces the heritage of Mitsubishi's phased array antennas(PAA's) development focusing on mobile satellite communication terminals from commercialization of product standpoint.

11:30 *Product Concepts for Land Mobile Satellite Communication Terminals in Ku-/Ka-Band*

Nevena Saponjic (Viasat Antenna Systems SA, Switzerland); Frank Klefenz (ViaSat Antenna Systems SA, Switzerland); Frédéric Bongard (Viasat Antenna Systems SA, Switzerland); Daniel Llorens (ViaSat Antenna Systems SA, Switzerland); Alexandre Boulle, Xavier Aubry and Alexander Butler (Viasat Antenna Systems SA, Switzerland); Ferdinando Tiezzi and Stefano Vaccaro (JAST SA, Switzerland)

The details of two product concepts and the hardware realization aspects for low profile Ku and Ka band land mobile terminals for high data rate satellite communications are described. Beside the competitive low cost approach, the non-obstructive design and lower weight are key issues for many applications to achieve a broad customer acceptance. The introduction of a proprietary planar antenna technology opens the possibility to meet these requirements.

11:50 *Asymptotic Formulas for the Radiation of a Dipole on a Strongly Elongated Convex Body:A Review*

Frederic Molinet (SARL MOTHESIM, France)

In this paper, the author gives a review on some asymptotic formulas which have been developed by different authors during the last ten years, for the field radiated by a source located on a strongly elongated convex body of revolution. Both perfectly conducting and impedance boundary conditions are considered. Explicit asymptotic solutions for the field on the surface in the paraxial direction are presented. Some numerical results on a spheroid are shown.

12:10 *A Collective UTD Ray Analysis for the Radiation from Conformal Linear Phased Array Antennas on Large Cylindrical Surfaces*

Prabhakar H. Pathak (The Ohio State University, USA)

A collective Uniform Geometrical Theory of Diffraction (UTD) solution is developed for describing, in a simple fashion, the radiation from a periodic, finite but long, linear array of elemental antennas mounted conformally on a larger canonical circular cylinder geometry which is assumed to be a perfect electric conductor (PEC). This work is relevant to the prediction of the performance of large and conformal electronically scanned phased arrays in modern applications. The collective UTD radiation field of the entire array in the presence of the cylinder, when observed at any point which is not too close to the array, is vividly described here in terms of just three propagating rays; one such ray arrives to an external observation point from an appropriate point within the array interior, while the remaining arrive from each of the two ends of the linear array, respectively.

TOP

CS44 Small Antennas: From Theory to Practice

Wireless Networks / Convened Session / Antennas

Oral Sessions: Room 341

Chairs: Eva Antonino Daviu (Universidad Politécnica de Valencia, Spain), Miloslav Capek (Czech Technical University in Prague, Czech Republic)

08:40 *Recoverable Energy and Small Antennas*

Guy A. E. Vandenbosch (Katholieke Universiteit Leuven, Belgium); Jiachen Wang (KU Leuven, Belgium)

The maximum "recoverable" energy of a small radiator is determined. This energy is defined as the maximum energy that can be recovered from the electromagnetic field distribution in entire space generated by the radiator up to the time point considered. It is shown that the concept of recoverable energy for small radiators leads to a quasi-constant future current. The question can be raised whether this "recoverable" energy can be identified with the stored energy for a small radiator.

09:00 ***Minimum Q-factors for Antennas***

Mats Gustafsson (Lund University, Sweden); Miloslav Capek (Czech Technical University in Prague, Czech Republic)

Optimization of antenna currents is used to determine lower bounds on the Q-factors for antennas. Minimum Q-factors for antennas with specified radiation patterns are reformulated in convex form and are hence easily solvable. Here, it is shown that the unconstrained case with minimum Q can be relaxed to a dual problem that is solved as a generalized eigenvalue problem. This dual problem determines the minimum Q-factors for problems without degenerate eigenvalues. Moreover, cases with degenerate eigenvalues are solved by perturbations of the problems.

09:20 ***Overcoming the Chu Lower Bound on Antenna Q with Highly Dispersive Lossy Material***

Arthur D Yaghjian (Electromagnetics Research Consultant, USA)

It is demonstrated by means of RLC circuit models of electrically small antennas that their isolated-resonance quality factors obtained from the "Q-energy" predicts their bandwidths with greater accuracy than the "equivalent-circuit" or the "electrodynamic" energies. Moreover, it is verified that the Q-energy cannot be considered stored energy in highly dispersive lossy material. Nonetheless, using tuning elements containing highly dispersive lossy material, the bandwidth of fifty-percent efficient electrically small dipole antennas can be designed with twice the bandwidth predicted by the Chu lower bound for the quality factor of fifty-percent efficient antennas.

09:40 ***Antenna Q Bounds for Given Directivity: a Case Study of a Directive Parasitic Element Antenna***

Lars Jonsson (KTH Royal Institute of Technology, Sweden); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Leonardo Lizzi (Université Côte d'Azur, CNRS, LEAT, France)

In certain communication applications it is advantageous to constrain the shape of the far-field, as to make it act as a spatial filter. This can mitigate interference from other antennas. Such constraints on the far-field behavior, in particular for small antennas tend to increase antenna Q rapidly. To begin to investigate the relation between antenna Q and such far-field bounds, we here consider a case-study with constraint on the partial realized directivity for a two and three parasitic element antenna. The aim is to compare these predictions with a realized parasitic element antenna of the same shape. Note that this paper is a work in progress, and the final comparison between the realized antenna and the fundamental limitations will be discussed at the presentation.

10:00 ***Small 4 Elements Bi-Directional Antenna for Indoor MIMO Base Station***

Rohani Bakar, Kanata Takahashi and Hiroyuki Arai (Yokohama National University, Japan); Yasuko Kimura and Taisuke Ihara (NTT DoCoMo, Inc., Japan)

A composite antenna of a notch antenna and a loop antenna has been developed for indoor MIMO base station. The composite antenna has dual polarized radiation patterns pointing to two different directions. The horizontally polarized wave is given by the notch element in x-axis direction while the vertically polarized wave is given by the loop element in y-axis direction. The combination of the two composite antennas produces dual polarized radiation patterns in bi-direction and has a good isolation between the elements. This MIMO antenna is designed for 4G applications with the resonance frequency at 3.5 GHz.

10:20 Coffee Break

10:50 ***Body-Worn 67:1 Bandwidth Antenna Using 3 Overlapping Dipole Elements***

Cedric Lee (The Ohio State University, USA); Dimitris Papantonis (Ohio State University, USA); Asimina Kiourti (The Ohio State University, USA); John L. Volakis (Ohio State University, USA)

We present a novel tightly coupled dipole array (TCDA) that achieves 67:1 bandwidth over the 30 MHz to 2 GHz frequency range. The design is extremely simple, and consists of 3 overlapping dipoles that are fed at 3 different locations to ensure uniform current flow. The overlapping dipoles are "printed" on a 0.3 mm-thick polymer substrate (εr=3), and "sandwiched" between two layers of flexible polymer (εr=3), each 2 cm thick. The TCDA occupies 1.4 m x 0.09 m, and is intended for on-body operation (e.g., placed along the arms). For example, the proposed antenna could be integrated into military uniforms to enhance quality of service in the SINCGARS, Air and Marine, UHF, UHF-Public Safety, and L bands.

11:10 ***Electrically Small Metamaterial-Inspired Antennas with Active Near Field Resonant Parasitic Elements: From Theory to Practice***

Ming-Chun Tang (College of Communication Engineering, Chongqing University, Chongqing, P.R. China); Richard W. Ziolkowski (University of Arizona, USA)

By augmenting several classes of metamaterial-inspired near-field resonant parasitic (NFRP) electrically small antennas (ESAs) with active (non-Foster) circuits, we have achieved performance characteristics surpassing their fundamental passive bounds. The designs not only have high radiation efficiencies, but they also exhibit large frequency bandwidths, large beam widths, large front-to-back ratios, and high directivities. Furthermore, the various initially theoretical and simulated designs have led to practical realizations. These active NFRP ESAs will be reviewed and recently reported designs will be introduced and discussed.

11:30 ***Propagation Considerations for Implantable Antennas***

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

Zagreb, Croatia)
The use of Body Area Networks has been increasing in the past decade due to the emergence of novel wearable and implantable services in the frame of e.g. healthcare, sports, security or fashion. As a result, the number of wearable and implantable antenna designs has exponentially increased in the same time frame. After this first boom in research related to W-BAN antennas, it is now time to learn from the achieved results, and try to understand the mechanisms limiting the performances of such radiators, in order to finally be able to develop useful practical design rules. In this contribution, we introduce a theoretical analysis of some canonical implanted W-BAN electromagnetic source scenarios, using a specifically developed numerical tool based on spherical wave expansions. The obtained results are used to give some design criteria for implantable antennas.

11:50 ***Small Printed Log-Periodic Array, Matched with an Active non-Foster Network***
Fernando Albarracín-Vargas (Universidad Carlos III de Madrid, Spain); Francisco Javier Herraiz-Martínez (Carlos III University in Madrid, Spain); Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain)
The design of a small printed-log-periodic antenna, loaded with an active matching network, for multiband applications is presented. A well-known, low-cost and low-profile antenna is re-engineered for including an additional impedance bandwidth in the lower UHF-band. The design method includes the use of the recently introduced sensitivity parameter Sens in order to find a suitable location for a transistor-based non-Foster network, realized with a Negative Impedance Converter (NIC).

12:10 ***Fano Matching Bandwidth Bounds for Small Loop Antennas Based on Spherical Wave Scattering***
Do-Hoon Kwon (University of Massachusetts Amherst, USA)
Fundamental impedance matching bounds for electrically small loop antennas are derived based on spherical wave scattering in the low-frequency limit. A small lossless loop antenna is represented as a two-port network between the excitation port and the fundamental TE spherical wave port. The low-frequency asymptotic expression for the wave reflection coefficient is found and the classical Fano approach is applied to derive integral equalities for the magnitude of the reflection coefficient. A basic loop, one with a series-C element, and one with a parallel-C element are analyzed. The bandwidth upper bounds as functions of the antenna dimension, the port impedance, and the circuit parameters are presented.

Wednesday, March 22, 08:40 - 10:20

C_P03 Urban Propagation

TOP

Cellular Communications / Regular Session / Propagation
Oral Sessions: Room 342A
Chairs: Jan M. Kelner (Military University of Technology, Poland), Taghrid Mazloum (Telecom ParisTech, France)

08:40 ***Investigation of Distributed and Collocated Base Stations in a Large Urban Massive MIMO Scenario***
Mehmet Mert Taygur (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)
An investigation of two Massive Multiple-Input Multiple-Output (MIMO) scenarios, with distributed and collocated transmitter antenna cases for a large dense urban environment, is performed based on ray tracing simulations. The scenarios consist of maximum 4096 transmitter antennas and 500 single antenna users which are at the ground level. The environment is one quarter square kilometre large and consists of 92 buildings with various heights. Channel matrices are obtained using ray tracing simulations. Maximum Ratio Transmission (MRT) and Minimum Mean Square Error (MMSE) linear beamformers are implemented during the post processing. The downlink performances are investigated. The results indicate that the variation of performance among the users can be different even though the average performance figures are not significantly different for the given deployment schemes.

09:00 ***Modeling the Distribution of the Arrival Angle Based on Transmitter Antenna Pattern***
Cezary Ziółkowski, Jan M. Kelner, Leszek Nowosielski and Marian Wnuk (Military University of Technology, Poland)
An angular distribution of received signals has a significant impact on their spectral and correlational properties. Most of angular dispersion models do not consider antenna patterns. The developed procedure for determining the propagation path parameters enables a wide range of assessment of the impact of the propagation environment on the received signal properties. In contrast to the other models, this procedure is based on a geometrical structure, which parameters are defined on the basis of power delay profile or spectrum This modeling method allows also the power radiation pattern (PRP) of the transmitting antenna. The aim of the paper is to present the influence of the transmitter antenna PRP on the scattering propagation paths that arrive at the receiver. This analysis is realized on the basis of simulations studies using the developed procedure. Presented in this paper procedure maps the effects of propagation phenomena that predominate in an azimuth plane.

09:20 ***Investigating the Overestimation of Base Station Exposure in Urban Environments Due to Assumption of Free Space Propagation***
Thomas Kopacz, Sascha Schießl and Dirk Heberling (RWTH Aachen University, Germany)

Safety assessment of exposure caused by cellular base stations based on calculation methods is often performed using free space propagation in order to include the worst case. For prospective technologies (e.g. small cells in the vicinity of people), this approach might lead to a high exploitation of exposure limits. This paper investigates the overestimation of downlink exposure being predicted with a free space propagation model in comparison to a deterministic 2D knife edge diffraction model in an urban environment for a rooftop mounted base station. The results show that overestimation is quite low in the vicinity of the base station, particularly in LOS regions. In a distance between 100 and 200 m the overestimation is constantly rising, whereas for distances larger than 200 m it stays nearly constant.

09:40 ***Assessment of RF Human Exposure to LTE Small- And Macro-Cells: UL Case***

Taghrid Mazloum (Telecom ParisTech, France); Bader Fetouri (Mobile Networks CTO - Nokia, France); Nabil Elia (ANFR, TelecomParisTech, France); Emmanuelle Conil (ANFR, France); Christophe Grangeat (Mobile Networks CTO - Nokia, France); Joe Wiart (Telecom ParisTech, France)

Small cells, novel low-powered base stations with local range, are nowadays investigated in order to improve the radio coverage and capacity in macro cell layer. The radio frequency exposure induced in such cells is unknown. Hence, we assess in this paper, through experimental measurements, the impact of an LTE small cell cluster on the radio frequency exposure induced by a mobile handset. With respect to macro cells, we show that the deployment of small cells provides better radio coverage in terms of throughput while minimizing the radio frequency exposure induced by the mobile handset.

10:00 ***Analysis of the Level-Crossing Rate and Average Duration of Fades of WSSUS Channels***

Matthias Pätzold (University of Agder, Norway); Nazih Hajri (Ecole Supérieure de Communications de Tunis, Sup'Com, Tunisia); Neji Youssef (Ecole superieure des communications de Tunis, Tunisia)

Studies of the level-crossing rate (LCR) and the average duration of fades (ADF) are so far only devoted to stochastic processes being a function of one independent variable, which is usually time or in some few cases frequency. In this paper, we study the LCR (ADF) of wide-sense stationary uncorrelated scattering (WSSUS) processes in the time-frequency domain. A closed-form solution will be derived for the so-called time-frequency LCR (ADF) of the absolute value of the time-variant transfer function (TVTF) of WSSUS processes. It is shown that the LCR (ADF) is circularly symmetric in the normalized time-frequency domain. The derived time-frequency LCR contains the time LCR and frequency LCR well known in the literature as special cases. The importance of the introduced time-frequency LCR is demonstrated by introducing a new method for the estimation of the Doppler spread and the delay spread from measured TVTFs of WSSUS channels.

TOP

B_P01 Biomedical Imaging

Biomedical / Regular Session / Propagation

Oral Sessions: Room 342B

Chairs: Panagiotis Kosmas (King's College London, United Kingdom), Andrea Massa (University of Trento, Italy)

08:40 ***Multi-Resolution Compressive Sensing Inversion of Scattering Data***

Lorenzo Poli (University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Andrea Massa (University of Trento, Italy)

This paper proposes a novel technique for retrieving the dielectric features of weak scatterers in microwave imaging by means of a Compressive Sensing (CS)- based method enhanced by a multi-zoom strategy. A Relevance Vector Machine (RVM) is used to invert the data of the problem recast in a Bayesian framework, exploiting the combination of the a-priori information on the sparseness of the unknowns and the acquired knowledge during the iterative multi-scaling methodology. Representative results are presented to illustrate advantages and limitations of the proposed method.

09:00 ***Inverse Source and Compressive Sensing for Qualitative Reconstruction***

Martina Teresa Bevacqua and Tommaso Isernia (University Mediterranea of Reggio Calabria)

A new linear approach for support reconstruction of both penetrable and impenetrable objects from the measurements of the scattered fields is introduced and described. The approach takes advantage from the fact that for both high conductivity and dielectric scatterers, induced and 'equivalent' currents can be considered localized on the boundary. Starting from these considerations, an ad hoc compressive sensing inspired inversion approach is formulated to localize and retrieve the shape of the unknown objects without a priori assumptions on them.

09:20 ***Exploiting Wavelet Decomposition to Enhance Sparse Recovery in Microwave Imaging***

Michele Ambrosanio (Università di Napoli Parthenope, Italy); Panagiotis Kosmas (King's College London, United Kingdom); Vito Pascazio (Università di Napoli Parthenope, Italy)

Over the last years, various new non-invasive methodologies have been proposed for medical imaging. Among them, microwave imaging (MWI) seems to be a promising technique for applications such as stroke detection and breast cancer imaging (BCI). This diagnostic modality is based on measurements of the scattered field outside an imaging domain, in which the object of interest is located. This inverse problem requires strategies such as regularization to increase the stability of the reconstructions. This work presents a method to increase stability based on exploiting the wavelet transform (WT) as a regularization strategy combined with a sparsity-based approach. The proposed technique is based on the theory of compressed sensing (CS) to treat the strong ill-

posedness of the non-linear electromagnetic inverse scattering (EIS) problem.

09:40 ***A Compressive Sensing Unmixing Algorithm for Breast Cancer Detection***
Jose Martinez Lorenzo and Richard Obermeier (Northeastern University, USA)
In this paper, we describe a novel unmixing algorithm for detecting breast cancer. In this approach, the breast tissue is separated into three components, low water content (LWC), high water content (HWC), and cancerous tissues, and the goal of the optimization procedure is to recover the mixture proportions for each component. By utilizing this approach in a hybrid DBT / NRI system, the unmixing reconstruction process can be posed as a sparse recovery problem, such that compressive sensing (CS) techniques can be employed. A numerical analysis is performed, which demonstrates that cancerous lesions can be detected from their mixture proportion under the appropriate conditions.

10:00 ***Application of the DBIM-TwIST Algorithm to Experimental Microwave Imaging Data***
Zhenzhuang Miao (KING'S COLLEGE LONDON, United Kingdom); Syed Ahsan and Panagiotis Kosmas (King's College London, United Kingdom); Jorge Alberto Tobon Vasquez, Francesca Vipiana, Mario Roberto Casu and Marco Vacca (Politecnico di Torino, Italy)
This work presents some preliminary results from applying our previously developed microwave imaging algorithm based on two-step iterative shrinkage/thresholding (TwIST) to data measured from an experimental microwave imaging system. Combining the distorted Born iterative method (DBIM) with the TwIST linear solver, our two-dimensional (2-D) algorithm is applied to reconstruct 2-D slices of the complex permittivity of the interrogated imaging domain. Experimental data are obtained by rotating a two-antenna system along the cylindrical imaging domain, which is filled with Triton X-100. The imaging object is an anatomically realistic breast phantom with a tube filled water representing the tumor-like target. Measurements are covered in the frequency range from 0.5 to 4.0 GHz. The paper presents reconstructed images at 900 MHz, while more results will be presented at the conference.

Wednesday, March 22, 08:40 - 12:30

CS48 THz Wireless Communications: from Components to Systems

TOP

High Data-rate Transfer / Convened Session / Antennas
Oral Sessions: Room 343
Chairs: Guillaume Ducournau (IEMN - Lille University, France), Frédéric Gianesello (STMicroelectronics, France)

08:40 ***Terahertz Communications Using Resonant-Tunneling-Diode Oscillators***
Safumi Suzuki (Tokyo Institute of Technology, Japan)
The recent progress in terahertz wireless data transmissions using resonant-tunneling-diode (RTD) oscillators is reported. RTD oscillators with wide modulation bandwidth (~30 GHz) were fabricated, and wireless data transmissions in the 500-GHz range were demonstrated. An error-free transmission data rate up to 22 Gbps and a transmission with bit error rate less than the forward error correction limit, up to 34 Gbps, were achieved. For alignment-free wireless communication in the polarization direction, an RTD oscillator integrated with a radial line slot antenna for circular-polarized radiation was proposed and fabricated. A sharp directivity and low axial ratio of polarization (2.2 dB) was achieved at 710 GHz.

09:00 ***Signal Quality Impairments by Analog Frontend Non-Idealities in a 300 GHz Wireless Link***
Ingmar Kallfass, Seyyid Dilek and Iulia Dan (University of Stuttgart, Germany)
This paper discusses the influence of non-idealities in the analog transmit and receive frontend of an MMIC-based 300 GHz wireless link on the receive signal quality. The degradation of EVM due to limited bandwidth and gain imbalance in the quadrature up- and down-converters is considered and compared to experimentally achieved data. Using adaptive equalization and quadrature error correction in the digital baseband, the measured EVM in a 1 m data transmission is improved by up to 4.5 dB from its raw value and stays below -12.75 dB for data rates of up to 36 Gbit/s with QPSK modulation. A frequency dependent theoretical analysis of quadrature gain imbalance allows to derive its impact on receiver EVM as a function of baud rate.

09:20 ***Scattering Center Determination for Integrated Antenna Measurements at mm-Wave Frequencies***
Linus Boehm (Ulm University, Germany); Christian Waldschmidt (University of Ulm, Germany)
In this paper the results of integrated antenna measurements are analyzed to identify the main reflection locations when measuring with wafer probes. Two different approaches are described and the measurement results for two different probe designs are shown. First, the main reflection center on the wafer probe is determined by analyzing the measured far field radiation pattern at 160 GHz. The second approach is based on an extrapolation measurement of the antenna. It is shown that the reflective areas can be identified for both probe designs. The results can be used to assess the measurement uncertainty and to quantify the measurement error.

09:40 ***Artificial Dielectric Enabled Antennas for High Frequency Radiation From Integrated Circuits***
Daniele Cavallo, Waqas Hassan Syed and Andrea Neto (Delft University of Technology, The Netherlands)

At millimeter and sub-millimeter wave frequencies, electronic circuits and antennas are often located on the same semiconductor chip to facilitate their interconnection. However, on-chip antennas are characterized by very poor radiation efficiency and extremely narrow bandwidth. This is because they are situated at small electrical distance from a ground plane that shields the antenna from the lossy bulk. High-permittivity superstrates can be located above the antennas to improve the impedance properties, but they support the propagation of surface waves which reduce the efficiency. Here we propose the use of artificial dielectric (AD) superstrates above the antennas to improve significantly their performance. Because of their anisotropy, AD slabs do not support surface waves, thus enabling high-efficiency designs. To clarify the concept, we investigate the property of a simple dipole antenna on chip in terms of impedance and efficiency. Full-wave simulations predict efficiency up to 87% with the presence of the AD.

10:00 ***Performance Evaluation of a First Phased Array Operating at 300 GHz with Horn Elements***

Sebastian Rey (Technische Universität Braunschweig, Germany); David Ulm and Thomas Kleine-Ostmann (Physikalisch-Technische Bundesanstalt, Germany); Thomas Kürner (Technische Universität Braunschweig, Germany)

The application of frequencies beyond 300 GHz in the so-called THz frequency range requires electronic beam steering, which can be realized by a phased array.In this paper, measurement results of a novel 300 GHz phased array antenna with horn elements and an envisagde gain of 20.7 dBi for THz communications are presented.The results are compared to simulations with respect to antenna patterns, gain, half power beam width, frequency dependenceof these and the matching of the antenna elements. An outlook towards measurements of antenna patterns of the array as a whole concludes the paper.

10:20 Coffee Break

10:50 ***Photonic Generation and Distribution of Coherent Multiband THz Wireless Signals***

Martyn Fice (University College London, United Kingdom); Haymen Shams (University College London (UCL), United Kingdom); Zhen Yang, Luis Gonzalez-Guerrero, Michele Natrella, Cyril Renaud and Alwyn Seeds (University College London, United Kingdom)

We discuss photonic generation of high-speed THz wireless signals, with particular reference to how multiband signals could be distributed over fibre networks from a central baseband unit equipped with a pool of optoelectronic components, allowing the remote antenna unit to be very simple, while delivering flexibility in terms of data rate and THz carrier frequency. The proposed scheme is demonstrated experimentally by generating a 5-channel multiband signal with aggregate data rate of 100 Gb/s and investigating the performance of each 20 Gb/s sub-band after transmission over a wireless link in the 220 - 280 GHz band.

11:10 ***High Efficiency UTC Photodiodes as Photonic Emitters for 300 GHz High Spectral Efficiency Wireless Communications***

Philipp Latzel (IEMN, France); Fabio Pavanello (IEMN, CNRS/LILLE 1, France); Sara Bretin and Maximillien Billet (IEMN, France); Emilien Peytavit (IEMN, CNRS, France); Jean-François Lampin (Lille University, France); Mohamed Zaknoune (Institute of Electronics, Microelectronics and Nanotechnology, France); Guillaume Ducournau (IEMN - Lille University, France)

This paper presents the development and use of high-efficiency Unitravelling carrier photodiodes for THz communications. Using these devices, high output power is obtained close to the mW level. THz wireless links demonstration is also presented using these devices, using high-level modulation schemes (QAM-16) and 32 Gbit/s data-rate. This result demonstrates the capability of the UTC-PD devices of combining high power level and a linear behavior, mandatory for high-spectral efficiency data links in the THz range.

11:30 ***Enabling Low Cost THz Radiating Source Leveraging Si Photonics, IC Packaging Substrate & 3D Printing Technologies***

Elsa Lacombe (University of Nice Sophia Antipolis & STMicroelectronics, France); Frédéric Gianesello (STMicroelectronics, France); Cyril Luxey (University Nice Sophia-Antipolis, France); Cedric Durand and Daniel Gloria (STMicroelectronics, France); Aimeric Bisognin (University Nice Sophia-Antipolis & STMicroelectronics, France); Diane Titz (University Nice Sophia Antipolis, France); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal)

Silicon technologies enable today the development of cost effective millimeter-wave applications (60 GHz wireless link for example). In order to achieve higher data rates (> 10 Gb/s), we can now consider the sub-THz frequencies in order to take advantage of wider frequency bands. In this context, the development of low cost and highly integrated Si-based sub-THz wireless chipset is a hot topic; industrial Si Photonic PIN Photo-Diode can be used as sub-THz source. But a key challenge is the design of antennas and packages able to support ultra-broad band sub-THz transmission in a cost effective manner. We propose here the design of a 200-280 GHz antenna integrated in an organic substrate packaging technology. Simulated performances exhibit a gain of >8 dBi over a 33% bandwidth. A 3D printed plastic lens is then added to the system in order to increase the achievable gain up to 20 dBi.

11:50 ***Interconnect and Packaging Technologies for Terahertz Communication Systems***

Goutam Chattopadhyay (JPL, USA); Theodore Reck and Cecile Jung-Kubiak (NASA-JPL, Caltech, USA); Maria Alonso-delPino (Jet Propulsion Laboratory, USA); Choonsup Lee (JPL, USA)

Using newly developed silicon micromachining technology that enables low-loss and highly integrated packaging solutions, we are developing vertically stacked transmitters and receivers at terahertz frequencies that can be used for communication and other terahertz systems. Although there are multiple ways to address the problem of interconnect and packaging solutions at these frequencies, such as system-on-package (SOP), multi-chip modules (MCM), substrate integrated waveguide (SIW), liquid crystal polymer (LCP) based multilayer technologies, and

others, we show that deep reactive ion etching (DRIE) based silicon micromachining with vertical integration allows the most effective solutions at terahertz frequencies

12:10 ***Fly's Eye Spherical Antenna System for Future Tbps Wireless Communications***

Nuria LLombart and Diego Emer (Delft University of Technology, The Netherlands); Marta Arias (Delft University of Technology, Germany); Earl McCune (RF Communications Consulting & Eridan Communications, USA)

In this work we present an antenna system capable of providing wireless data rates orders of magnitude above the current mobile solutions with a comparable RF power requirement. The proposed solution is based on a sphere shaped 2D (two-dimensional) lens antenna array that generates multiple-directive beams. A full 360deg coverage is achieved via a combination between Space Division Multiplexing (SDM) and a 4 channel frequency re-use. As a test case scenario, we tackle future capacity demands in sport stadiums during high-profile matches. Each antenna directive beam links a set of users/spectators sitting in the stadium tribune with a central base station. The use of multiple high frequencies line of sight links (120GHz) makes possible wireless data rates of 12Tbps to serve 80.000 users with a reasonable overall radio frequency (RF) power consumption (≈ 50W) and user terminal transmit power (≈15dBm).

TOP

CS27 Mm-wave GAP Waveguide Technology

Future Applications / Convened Session / Antennas

Oral Sessions: Room 351

Chairs: Ahmed Kishk (Concordia University, Canada), Jian Yang (Chalmers University of Technology, Sweden)

08:40 ***New Feeding Network Topologies for High-Gain Single-Layer Slot Array Antennas Using Gap Waveguide Concept***

Miguel Ferrando-Rocher, Alejandro Valero-Nogueira and José Ignacio Herranz-Herruzo (Universidad Politécnica de Valencia, Spain)

This paper describes a low-loss ridge gap waveguide (RGW) to groove gap waveguide (GGW) transition. Transitions from RGW to GGW and vice versa can be advantageously combined leading to very compact feeding networks. Interestingly, these transitions circumvent the 180 deg phase difference in E-plane power splitters, facilitating in-phase corporate feeding networks based on such dividers. Using these transitions a first prototype of a 4x4 single-layer slot array antenna is presented. This antenna exhibits several appealing features for contemporary applications: single-layer, compact, symmetrical, and both radiation pattern bandwidth and impedance bandwidth greater than 14 % at V-band (57-66 GHz).

09:00 ***Wideband Glide-symmetric Holey Structures for Gap-waveguide Technology***

Mahsa Ebrahimpouri (KTH Royal Institute of Technology, Sweden); Eva Rajo-Iglesias (University Carlos III of Madrid, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

In this paper, the stop-band of two different holey glide-symmetric EBG lattices is studied. The results show that glide-symmetric EBG structures have potential to achieve wide stop-bands by polygonal lattices. Potential application of the proposed EBG structure in gap-waveguide technology is discussed in the second part of the paper.

09:20 ***Design of Antenna Feed with Amplified Power Distribution Using Groove-Gap Waveguide Technology***

Carlos Sanchez-Cabello, Luis Inclan-Sanchez, Jose-Luis Vazquez-Roy and Eva Rajo-Iglesias (University Carlos III of Madrid, Spain)

A contactless in-line wideband and low-loss microstrip to groove-gap (GG) waveguide transition based power divider operating at X-band is presented. It can be scaled to mm-wave frequencies and beyond without too many mechanical problems, due to the innovative Gap Waveguide technology. The principle of operation is based on transforming EM fields from a SIW to a groove-gap (GG) waveguide mode via near field electromagnetic coupling. This is advantageous since the proposed solution avoids the use of metal contact between the SIW and one of the waveguide parts. Furthermore, metamaterial-based gap waveguide technology provides a resonance-free packaging solution for the integrated MMIC amplifier. We propose to use this transition in a power divider scheme to provide distributed power amplification in groove-gap (GG) waveguide technology to be applied to antenna systems in this same technology.

09:40 ***Gap Waveguide Based Planar Antenna for 140 GHz (D-band)***

Sofia Rahiminejad and Ashraf Uz Zaman (Chalmers University of Technology, Sweden); Sjoerd Haasl (Royal Institute of Technology, Sweden); Peter Enoksson (Chalmers University of Technology, Sweden)

This paper presents a polymer gap waveguide antenna operating at 140 GHz (D-band). The antenna has three layers and all are suitable for MEMS fabrication. The polymer SU8 will be used for all these layers and after they will be coated with gold. In this paper the top plate is fabricated and is presented together with the design, simulation results, and the fabrication process. The design of the complete antenna shows a simulated reflection coefficient bandwidth of about 15% (S11 < -10 dB), and a simulated directivity of about 34 dBi. Index Terms—Antenna, Microsystem technology, D-band, SU8.

10:00 ***High Gain Circularly Polarized Slot Antenna Based on Microstrip-ridge Gap Waveguide Technology***

Fangfang Fan and Zehong Yan (Xidian University, P.R. China)

This paper presents a novel circular polarized slot antenna design using microstrip-ridge gap waveguide technology, it possesses the easy manufacturing since it realizes the gap waveguide with PCB process. The antenna is composed of two substrates, by using the ring slot with a shorted strip on the upper substrate and the EBG textures located on the lower substrate, the circular polarized characteristic of the antenna is obtained, the simulated results with CST simulation software show the antenna has the impedance bandwidth of 13.8% (72.1GHz-82.8GHz, |S11|<-10dB), and the axial ratio is from 75.2GHz-79.9GHz (AR<3dB) with 6% circular polarization bandwidth. And also the microstrip slot antenna is designed and compared with the antenna in this paper. The compared results give the strong evidence that the microstrip-ridge gap waveguide circular polarized slot antenna has wider bandwidth and higher gain.

10:20 Coffee Break

10:50 *W-band Wideband and High-Gain TE220-Mode Cavity-excited Circularly Polarized Antenna Array with Gap Waveguide Feeding Network*

Hao Wang (Nanjing University of Science & Technology, P.R. China)

In this communication, a TE220 mode substrate integrated cavity (SIC) excited 2×2 circularly polarized (CP) antenna subarray for wideband and high-gain W-band array application is presented. This antenna subarray is designed by using of two low-cost double-side printed circuit broads (PCBs). By combining the rectangular slot and L-shaped probe, a CP antenna can be achieved. The transmission loss caused by divider can be reduced by using the high order mode substrate integrated cavity to excite the slot antenna subarray. Furthermore, such use reduces processing difficulty and fabrication cost. To reduce the loss further, the microstrip-based ridge gap waveguide (GWG) technology is applied to feed the SIC subarrays. Moreover, a linear polarization (LP) slot antenna is also designed to illustrate the operation mechanism of the proposed CP antenna. To validate our design, an 8×8 antenna array with 4×4 SIC subarrays has been fabricated and measured.

11:10 *Characteristics of 3D Printed Gap-Waveguide Components*

Zoran Eres (Rudjer Boskovic Institute, Croatia); Mladen Vukomanovic, Marko Bosiljevac and Zvonimir Sipus (University of Zagreb, Croatia)

Novel manufacturing technologies such as additive manufacturing or 3D printing allow many simplifications in the production of electromagnetic components. In this paper we focus on the characteristics of the components based on gap-waveguide technology and manufactured using 3D printing after which chemical copper electro-plating is performed. This is important since gap-waveguides are quite complex structures from manufacturing point of view due to multiple small metallic parts. For this purpose we have designed a groove gap-waveguide demonstrator at 10 GHz and a novel gap-waveguide leaky-wave antenna at 30 GHz which can be easily integrated with both the new gap waveguide and the traditional waveguide technology. Through simulations and measurements we will try to highlight the benefits and problems of this 3D technology in the high-frequency components prototyping.

11:30 *Millimeter Wave Contactless Microstrip-Gap Waveguide Transition Suitable for Integration of RF MMIC with Gap Waveguide Array Antenna*

Uttam Nandi, Ashraf Uz Zaman, Abbas Vosoogh and Jian Yang (Chalmers University of Technology, Sweden)

A new simple transition from a microstrip to gap waveguides has been proposed in this paper. The transition has been implemented for ridge gap waveguide and a groove gap waveguide. The cavity coupling is used to couple the waves between the microstrip and the gap waveguides. This cavity acts as a backshort in the transition region and the microstrip lies inside the waveguide, which provides a solution to integration of RF MMIC circuits with the feed-network of the gap waveguide array antenna. Roger 3010 (Er=10.2) was used as the microstrip substrate for these transitions. The optimised back-to-back Ridge Gap Waveguide (RGW)-microstrip transition shows relative bandwidth of 21% for S11<20 dB and Groove Gap Waveguide (GGW)-microstrip transition shows relative bandwidth of 20% for S11<17 dB. The insertion losses are better than 0.5 dB in the designed frequency bands for both the RGW and GGW transitions.

11:50 *A K-Band Planar Slot Array Antenna on a Single Layer Ridge Gap Waveguide*

Zeinab Talepour (K. N. Toosi University of Technology, Iran); Ali Khaleghi (K.N.Toosi University of Technology)

A K-band slot array antenna is developed by using ridge gap waveguide technology in a single layer metal structure. A power divider of 1:4 is used to feed the ridge gap waveguide and the slots. The power divided itself is fed with a waveguide transition. Detail design of the antenna is presented. The antenna has the impedance bandwidth of 9% at the center frequency of 38.5 GHz, The antenna gain is 21 dBi and the side lobe level is less than 12 dB.

12:10 *Contactless Flange Adapters for Mm-Wave Measurements*

Esperanza Alfonso, Simon Carlred, Stefan Carlsson and Lars-Inge Sjöqvist (Gapwaves AB, Gothenburg, Sweden)

In this paper leakage-free contactless flange adapters for mm-wave frequencies are presented. The adapters are compatible with standard rectangular waveguide flanges, covering the whole operational bandwidth of those. They are placed in between standard waveguides in order to avoid leakage at the joints between flange surfaces. Unlike standard flanges, the adapters are contactless, i.e., they do not require to be in good electrical contact when connected to the flange surfaces. Therefore, the use of fastening screws can be replaced by more practical ways of interconnection, e.g., magnets. In the end, the use of such adapters between standard waveguide flanges allows for faster, accurate and reliable mm-wave measurements.

Radars / Convened Session / Propagation
Oral Sessions: Room 352A
Chairs: Matteo Pastorino (University of Genoa, Italy), Giuseppe Schettini (Roma Tre University, Italy)

08:40 ***Air-Launched and Ground-Coupled GPR Data***
Nectaria Diamanti and A. Peter Annan (Sensors & Software Inc., Canada)
Ground penetrating radar (GPR) sees a wide range of applications; some investigations, such as assessment of roads and reinforced concrete bridge decks, often employ vehicle mounted GPRs. When mounted on vehicles, GPR can be deployed in an air-launched or ground-coupled form. The trade-offs in GPR performance are seldom discussed and not well understood for the two approaches of deployment. Further, what maximum height is acceptable for being ground-coupled and what is the minimum height to be considered air-launched? Our goal is to study the behaviour of direct air/ground and reflected waves as antennas are moved from being directly on ground to being in air (i.e., at a height off the air-ground interface, where the surface reflection is clearly isolated from the direct signal). We present both numerical simulation results and observed GPR data to study and characterize responses. Results confirm the generally observed behavior and provide insight into the trade-offs.

09:00 ***Antenna Design for Microwave Tomography Imaging of High Contrast Mediums***
Samuel Poretti, Matteo Lanini, Andrea Salvadè, Manuela Maffongelli and Ricardo D. Monleone (University of Applied Sciences of Southern Switzerland, Switzerland)
A new multistatic microwave imaging system containing specially designed antennas to avoid strong reflections at the interface to material samples with high dielectric constant is presented. The structure consists of a switched antenna array put in direct contact with the material in analysis and able, thanks to the antenna design, to minimize the interface impedance mismatch.

09:20 ***Buried Object Detection and Imaging Through Innovative Processing of GPR Data***
Marco Salucci (ELEDIA Research Center, Italy); Lorenza Tenuti (ELEDIA Research Center, University of Trento, Italy); Lorenzo Poli and Andrea Massa (University of Trento, Italy)
An innovative two-dimensional (2D) inverse scattering (IS) approach for processing Ground Penetrating Radar (GPR) data is presented to retrieve the electromagnetic characteristics of a buried domain. The developed GPR-IS approach exploits a multi-frequency (MF) strategy to deal with the wideband nature of the available measurements and a multi-resolution (MR) scheme to reduce the ratio between problem unknowns and informative data. Moreover, a customized Particle Swarm Optimizer (PSO) is exploited in order to overcome the limitations of deterministic approaches in finding the global optimum of the arising MF cost function, which is characterized by a high density of local minima (i.e., false solutions).

09:40 ***Direct Scattering Methods in Presence of Interfaces with Different Media***
Cristina Ponti and Giuseppe Schettini (Roma Tre University, Italy)
Several techniques have been developed to solve the direct scattering problem from targets involving different media and interfaces. For the case of stratified media and embedded targets, different formulations based on integral equations solved with method of moments have been proposed. Time-domain methods have the advantage to return results in the form of radargrams typical of measurements with pulsed techniques. Among them, the Finite-Difference Time-Domain method is widely used due to its high flexibility in the simulation of targets and backgrounds of arbitrary shape. For the case of targets with canonical shape, i.e., circular cross-section cylinders, in a non-homogeneous background, the Cylindrical Wave Approach gives a semi-analytical solution that is fast and accurate.

10:00 ***Microwave Imaging of Non-weak Targets in Stratified Media via Virtual Experiments and Compressive Sensing***
Roberta Palmeri (University of Reggio Calabria, Italy); Martina Teresa Bevacqua (University Mediterranea, Italy); Loreto Di Donato (University of Catania, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Tommaso Isernia (University of Reggio Calabria, Italy)
Tomographic approaches represent an emerging way to process GPR data and to investigate stratified media, since they allow to obtain images that are more readable than those achieved with standard data processing, which require human expertise and may show high probability of false alarms. In this contest, an efficient inverse scattering strategy is proposed to achieve dielectric characterization of buried objects in lossy and stratified soils. The approach exploits the framework of the "virtual scattering experiments" in a stratified media, thus allowing to deal with not only the non linearity of the underlying physical phenomena, but also to counteract the difficulty arising from the aspect limited measurement configuration adopted in GPR surveys. The proposed method is tested through a numerical example, by considering Compressive Sensing regularization scheme in order to enhance imaging resolution capabilities.

10:20 Coffee Break

10:50 ***Near-Field Focusing Technique for Enhanced Through-the-Wall Radar***
Sandra Costanzo and Giuseppe Di Massa (University of Calabria, Italy)
The adoption of a Bessel beam source is proposed in this work as localized near-field antenna for through-the-wall radar applications. The basic idea is to exploit all appealing features of Bessel beams, in terms of ideally infinite propagation depth, narrow beam pattern and field invariance on the transverse plane, to enhance both the resolution as well as the robustness towards clutter effects of new generation through-the-wall systems.

11:10 ***Numerical Analysis of the Performance of a Multi-Frequency Inversion Scheme for Subsurface Prospection***
Alessandro Fedeli, Matteo Pastorino and Andrea Randazzo (University of Genoa, Italy)
An analysis of the performance of a multi-frequency inverse-scattering algorithm for imaging of buried scenarios is

reported in this paper. The considered inversion procedure is based on the use of a regularization scheme in the Lp Banach spaces able to solve the full non-linear half-space inverse scattering problem. The effects of different configurations of the soil are evaluated by means of numerical simulations.

11:30 ***Oblique Incidence Scattering by a Periodic Cylinder Array with Heterogeneous Cylinders***

Koki Watanabe (Fukuoka Institute of Technology, Japan)

This paper deals with the electromagnetic scattering of a plane-wave obliquely incident on a periodic circular cylinder array including heterogeneous cylinders, and shows a spectral-domain formulation based on the recursive transition-matrix algorithm. Generally, the fields in imperfectly periodic structures have continuous spectra in the wavenumber space, and the spectral-domain approaches require an artificial discretization in the wavenumber space. The present formulation also uses a concept of the pseudo-periodic Fourier transform, and the discretization scheme can be considered only inside the Brillouin zone.

11:50 ***Buried Targets Detection from Synthetic and Measured B-scan Ground Penetrating Radar Data***

Xiang Liu, Mohammed Serhir, Abelin Kameni, Marc Lambert and Lionel Pichon (GeePs- Group of electrical engineering, Paris)

The localization of buried targets using Ground Penetrating Radar (GPR) is dealt with. The bi-static GPR is made of two identical Vivaldi antennas operating from 0.5 GHZ to 3.5 GHz and installed in front of a sand box. The experimental data acquired in a controlled laboratory environment are validated by electromagnetic simulation. Then, both synthetic and experimental data are processed to detect the buried targets via three imaging methods. The targets localization is achieved from the GPR B-scan data. The results obtained via Stripmap SAR, Frequency-Wavenumber (F-K) migration and Kirchhoff migration are presented and compared.

12:10 ***High Capacity Imaging Using an Array of Compressive Reflector Antennas***

Jose Martinez Lorenzo, Ali Molaei, Galia Ghazi and Juan Heredia-Juesas (Northeastern University, USA); Hipólito Gómez-Sousa (Northeastern University)

This paper presents a novel high sensing capacity compressive imaging system, which is capable of imaging human-size targets. The system uses an array of Compressive Reflector Antennas (CRAs) in order to extend the imaging domain of a single CRA. Moreover, the multi-static electromagnetic cross-coupling of adjacent CRAs in the array is used as a mechanism to improve the imaging performance. A physical optics method is used as a forward model; and the Total Variation norm option, in the NESTA software, is used for performing the compressive imaging. Preliminary results show that the system is capable of providing an accurate reconstruction of a tesselated model of a human body.

Wednesday, March 22, 08:40 - 10:20

L_A03 MIMO & Smart Antennas

TOP

Localization & Connected Objects / Regular Session / Antennas

Oral Sessions: Room 352B

Chairs: Nima Jamaly (Swisscom, Switzerland), Mario Schühler (Fraunhofer Institute for Integrated Circuits IIS, Germany)

08:40 ***Large Dielectric Resonator Antenna ESPAR for Massive MIMO Systems***

Reza Movahedinia (Concordia University, Montreal, Quebec H3G 1M8, Canada); Mohammad Reza Chaharmir (Communications Research Centre, Canada); Abdel R. Sebak and Ahmed Kishk (Concordia University, Canada)

A large array of dielectric resonator antenna (DRA) based on Electrically-Steerable Parasitic Array Radiator (ESPAR) concept is presented for massive MIMO application. The proposed array consists of 18 sub-arrays while each subarray has three single units. Each single antenna units consist of four driven DRA, coupled to the parasitic DRAs in their E- and H-Planes. All the antenna elements placed in an interleaved arrangement which surpass the grating lobes with better scanning capabilities in all azimuthal directions. With the beam scanning capability feature of each sub-array, the proposed array can be a good candidate for massive MIMO and mm-wave application.

09:00 ***Throughput Estimation for 2 x 2 MIMO System with Single Leaky Feeder Cable***

Nima Jamaly, Damiano Scanferla and Hugo Lehmann (Swisscom, Switzerland)

The current paper deals with application of leaky feeder cables (LFCs) in linear-cells MIMO systems. We first revisit the method whereby we can map the measured channel data to throughput in an LTE system. Later we show that feeding an LFC from its both ends by two independent signals can potentially lead to a promising 2x2 MIMO system with a desirable throughput. Our results also interestingly demonstrate that feeding an LFC from both ends yields a constant average throughput all along the cable. However, the corresponding average throughput is dependent on the length of the cable and its longitudinal loss. For very long LFCs, the system may also convert to rank one system. We discuss about this case too.

09:20 ***On RSSI-Based Direction-of-Arrival Estimation Using Multibeam Antennas***

Mario Schühler (Fraunhofer Institute for Integrated Circuits IIS, Germany); Lars Weisgerber and Burak Sahinbas (Fraunhofer IIS, Germany)

An approach for direction-of-arrival estimation is presented that relies on a multibeam antenna. The antenna

provides a pre-defined set of radiation patterns with distinct main directions. The approach considers only magnitudes of a received signal after its decomposition by means of a beam-forming network. Its application to measured signals obtained from an experimental setup is discussed, revealing that the resolution of the direction estimated is not limited by the beamwidth of the radiation patterns.

09:40 ***AoA and Source Polarization Estimation with Circularly Polarized Multibeam Antenna Using MUSIC Algorithm***

Burak Sahinbas and Lars Weisgerber (Fraunhofer IIS, Germany); Mario Schühler (Fraunhofer Institute for Integrated Circuits IIS, Germany)

The angle-of-arrival estimation algorithm MUSIC using a multibeam antenna was investigated. The antenna is composed of four circularly polarized antenna elements and a beam-forming network, which provides a switchable set of radiation patterns with distinct main lobe directions. Circularly polarized lobes are not affected from random source inclinations in terms of polarization losses. But they have a limited axial ratio beamwidth, being a limitation for direction finding algorithm based on phase difference. This limitation is illustrated and utilizing the MUSIC algorithm. Compensation of the effect of source inclination on the direction of arrival estimation with a multibeam antenna is presented.

10:00 ***Achieving Physical Layer Security with Massive MIMO Beamforming***

Elias Yaacoub (Arab Open University, Lebanon); Mohammed Al-Husseini (Beirut Research and Innovation Center, Lebanon)

Physical layer security allows secure communications between a source and destination without the need to resort to key-based encryption techniques. Its increasing importance stems from the difficulty of implementing advanced encryption techniques in certain networks, such as the internet of things (IoT). In this paper, physical layer security is implemented by using massive multiple input multiple output (MIMO) techniques. Specifically, beamforming with large cylindrical antenna arrays is investigated. These arrays allow the transmission of both the useful signal to the destination and the jamming signal to the eavesdropper without resorting to the help of other nodes for relaying the signal and/or jamming the eavesdropper. Simulation results show that high levels of secrecy capacity can be achieved with the proposed approach.

TOP

CS10 Characteristic Mode Analysis for Platform-Mounted Antenna Design

Methods & Tools / Convened Session / Antennas

Oral Sessions: Room 353

Chairs: Yikai Chen (University of Electronic Science and Technology of China, P.R. China), Simone Genovesi (University of Pisa, Italy)

08:40 ***Aircraft Antenna Placement Using Characteristic Modes***

Martin Vogel (Altair Engineering, USA); Willem J Strydom (Altair Development S.A. (Pty) Ltd, South Africa); Ulrich Jakobus (Altair Engineering GmbH, Germany); Peter Futter (Altair Development S.A. (Pty) Ltd, South Africa)

This paper illustrates the use of Characteristic Mode Analysis in FEKO to synthesize a desired combined antenna pattern of multiple antennas mounted on an aircraft, and to mitigate co-site interference between antennas on an aircraft.

09:00 ***Characteristic Mode Control Via Partial Coating of Reactive Components on Conducting Surfaces***

Sai Ho Yeung and Chao-Fu Wang (National University of Singapore, Singapore)

Characteristic mode control via partial coating of reactive components on top of conducting surfaces will be investigated in this study. The objective of the research is to lower the resonant frequency of a particular characteristic mode that has the desired radiation pattern, and excite it for radiation. The control can be implemented by loading capacitive and inductive components on top of conducting surfaces. For demonstration purpose, capacitive components are coated on a conducting surface to lower the resonant frequency of a particular characteristic mode, which radiates along the horizontal plane.

09:20 ***Design of Vehicle-Mounted, Compact VHF Antennas Using Characteristic Mode Theory***

Ting-Yen Shih and Nader Behdad (University of Wisconsin-Madison, USA)

Compact and low-profile VHF antennas with enhanced bandwidth have a wide spectrum of applications in both commercial and military communication systems. Having both of these criteria in a single antenna, however, is very challenging. In this paper, we demonstrate a method for bandwidth enhancement of vehicle-mounted electrically-small antennas operating in the VHF band. In this method, the vehicle platform is considered to be the major part of the radiating structure, while a meandered monopole antenna is used as a capacitive coupling element to excite a desired set of characteristic modes of the platform. The size of the coupling element is 0.06lambda x 0.06lambda x 0.06lambda, where lambda is the free-space wavelength at the frequency of operation, 60 MHz (ka = 0.47). The proposed approach was employed to successfully enhance the bandwidth of a vehicle-mounted VHF antennas by at least 400%.

09:40 ***Excitation of Multiple Characteristic Modes on a Three Dimensional Platform***

Simone Genovesi (University of Pisa, Italy); Francesco Alessio Dicandia (Università di Pisa, Italy); Agostino Monorchio (University of Pisa & CNIT, Italy)

This work is a preliminary investigation of the possibility to excite a set of characteristic modes on a three dimensional object. The aim of this study is to provide guidelines for the excitation of characteristic modes on a

complex platform in order to obtain a pattern reconfigurable.

10:00 ***HF Band Aircraft Integrated Multi-Antenna System Designs Using Characteristic Modes***

Chenghui Wang and Yikai Chen (University of Electronic Science and Technology of China, P.R. China); Shiwen Yang (University of Electronic Science and Technology of China (UESTC), P.R. China)

In this paper, we present an approach to design conformal HF band multi-antenna system for aircraft using the characteristic mode theory. The whole antenna system generates omni-directional radiation pattern at 18 MHz, NVIS radiation pattern at 8 MHz and downward radiation pattern at 28 MHz. The antenna system is realized by a pair of folded monopole exciters embedded on the vertical stabilizers, a pair of probes to excite the long notches cut in the vertical stabilizers, and a pair of folded monopole exciters embedded on the horizontal stabilizers, respectively. Properly designed matching networks are used to match the input impedance of these exciters. The simulated input impedance bandwidth of the three antennas are 1.6%, 7.6%, and 12.5%, respectively. The port isolation is more than 10 dB across the whole interested frequency band.

TOP

Sp_P02 Tropospheric Propagation for Space Applications II

Space / Regular Session / Propagation
Oral Sessions: Room 362/363
Chairs: Lorenzo Luini (Politecnico di Milano, Italy), Michael Schönhuber (Joanneum Research, Austria)

08:40 ***Improving Weather-Forecast Based Model Chain to Optimize Data-Volume Transfer for Ka-band Deep-Space Downlinks***

Marianna Biscarini, Frank S. Marzano and Luca Milani (Sapienza University of Rome, Italy); Mario Montopoli (ISAC CNR, Italy); Klaide De Sanctis (HIMET, Italy); Saverio Di Fabio (CETEMPS, Italy); Domenico Cimini (IMAA-CNR & CETEMPS University of L'Aquila, Italy); Maria Montagna (SciSys @ ESA, Germany); Mattia Mercolino and Marco Lanucara (European Space Agency, Germany)

In this work, we expose the fine-tuning and validation processes (based on radiometric and radiosounding measurements) of a preiously developed WF-based technique. The latter is a model chain that exploits weather forecasts (WF) for the optimization of deep-space satellite downlink at Ka-band. The presented results confirm the reliability of the WF-based technique and its better performances with respect to more traditional techniques. In terms of yearly-received data-volume, we have found a gain of about 15% to 24% associated with a decrease of the yearly lost data. These results make the proposed WF-based technique actually suitable for planning deep-space satellite-transmissions at Ka-band.

09:00 ***About Seasonal Variations of Specific Attenuations Derived from DSD Measurements***

Michael Schönhuber, Jesus Peña Mateos and Karin Plimon (Joanneum Research, Austria)

Reliable estimates of satellite channel characteristics are of great importance for satellite communications, especially with use of even higher frequencies as Ka-band and in near future Q- and V-band. At a given rain rate the shape of rain drop size distributions (DSDs) considerably influences the corresponding specific attenuation. In previous work it was shown, that annual DSD statistics give evidence for geographical dependence. In this paper first results indicate that the seasonal variations of the DSD shapes are minor in comparison to the geographical dependencies. This points to a conclusion that a global map of annual DSD statistics will give a valuable contribution to satellite link parameter estimates.

09:20 ***Improved Scaling Factor for Long-Term Rain Attenuation Statistics as a Function of Link Elevation***

Luciano M Tomaz (Politecnico di Milano); Carlo Capsoni and Lorenzo Luini (Politecnico di Milano, Italy)

The attenuation due to rain is one of the main impairments in satellite communications. It is well known that rain attenuation is dependent on the elevation angle of the link, being more severe at low elevation angles; this has a definite impact on the design of TLC and data download systems based on LEO satellites. This paper presents a simple model to scale long-term rain attenuation statistics as a function of link elevation angle. The model receives as input the known complementary cumulative distribution (CCDF) at a specific elevation and generates the CCDF scaled at other elevation angles.

09:40 ***Statistics of Attenuation Due to Rain Affecting Hybrid FSO/RF Link: Application for 5G Networks***

Umair Ahmed Korai (University of Strathclyde, United Kingdom & IICT, Mehran University of Engineering and Technology, Jamshoro, Pakistan); Lorenzo Luini (Politecnico di Milano, Italy); Roberto Nebuloni (Ieiit - Cnr, Italy); Ivan Glesk (University of Strathclyde, United Kingdom)

This paper shows that FSO could be an option for backhauling among microcells in future 5G systems in areas where fog is not a concern as very short LOS links (few hundred meters) would be required. In this respect, monthly CCDFs of rain attenuation at both RF (28 GHz) and optical bandwidth have been calculated in the area of Hyderabad (Pakistan). FSO links with simple OOK modulation would be able to reach targeted data rate of hundreds of Gbps for 99.99% of time provided the link length is less than few hundreds of meters

10:00 ***Impact of Rain Attenuation on 5G Millimeter Wave Communication Systems in***

Equatorial Malaysia Investigated Through Disdrometer Data

Hong Yin Lam (Universiti Tun Hussein Onn Malaysia, Malaysia); Lorenzo Luini (Politecnico di Milano, Italy); Jafri Din and Manhal Jaafar Alhilali (Universiti Teknologi Malaysia, Malaysia); Siat Ling Jong (Universiti Tun Hussein Onn Malaysia, Malaysia); Félix Cuervo (Joanneum Research, Austria)

Next-generation 5G cellular networks are expected to operate on the millimeter wavelength frequencies (e.g., 28 GHz and 38 GHz) to offer broader bandwidths and higher data rates. In this frequency band, rain is a major impairment to received signal power. This work aims to improve predictions of rain attenuation for 5G wireless networks operating at 28 GHz and 38 GHz in heavy rain regions, by exploiting three years of raindrop size distribution data collected at Kuala Lumpur (Malaysia). The specific attenuation is calculated by means of point matching technique and each minute of DSD data. The empirical relationship between specific attenuation and rainfall intensity are subsequently derived and compared with those for Rec. ITU-R P.838-3 and Singapore results. The results indicate substantial local deviations from the ITU-R model, especially at 38 GHz. These results offer important information for predicting rain attenuation of 5G wireless communication systems in heavy rain regions.

Wednesday, March 22, 08:40 - 12:30

SWS_05: Revision and Changes to the IEEE 149 Standard on Antenna Measurements (AMTA Workshop)

TOP

WG Meetings & WorkShops: Room 315

Chairs: Lars Foged (Microwave Vision Italy, Italy), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Wednesday, March 22, 10:50 - 12:30

C_P04 Millimeter Wave Radio Channels II

TOP

Cellular Communications / Regular Session / Propagation

Oral Sessions: Room 342A

Chairs: Reiner S. Thomä (Ilmenau University of Technology, Germany), Jianyao Zhao (Huawei Technologies Co., Ltd., P.R. China)

10:50 ***Millimeter-Wave Outdoor-to-Indoor Channel Measurements at 3, 10, 17 and 60 GHz***

Cheikh Diakhate (Telecom ParisTech, Université Paris-Saclay & Orange Labs, France); Jean-Marc Conrat (Orange Labs, France); Jean Cristophe Cousin (Ecole Nationale Supérieure de Télécommunications, France); Alain Sibille (Telecom ParisTech, France)

Millimeter-Wave (mmW) communication systems, capable of achieving high data rates thanks to the large bandwidth available in this frequency range, are a promising 5G technology. Studies in this paper investigate the radio propagation channel at 3, 10, 17 and 60 GHz in an Outdoor-to-Indoor (O2I) scenario. Measurements were conducted using a wideband channel sounder to derive channel parameters such as building penetration losses and channel delay spread values. It was observed that signal attenuation is strongly material-dependent and also, to some extent, frequency-dependent as well. However, the delay spread is weakly correlated with the frequency.

11:10 ***A 32 GHz Urban Micro Cell Measurement Campaign for 5G Candidate Spectrum Region***

Mamadou Dialounke Balde (University of Rennes 1, France); Joni Vehmas, Sinh Nguyen and Katsuyuki Haneda (Aalto University, Finland); Heykel Houas (ANFR); Bernard Uguen (University of Rennes I, France)

A 32 GHz Urban Micro cell (UMi) measurement campaign is presented in this paper. A path loss model in line of sight (LOS) for the 5G frequency band 31.8-33.4 GHz is provided and different classical key channel metrics are investigated. Furthermore, we corroborate that no significant difference is noted between the 28 GHz and 32 GHz frequency bands with respect to the main channel characteristics.

11:30 ***28 GHz Millimeter-Wave Measurements and Models for Signal Attenuation in Vegetated Areas***

Junghoon Ko (Korea Advanced Institute of Science and Technology (KAIST), Korea); Yun-Seok Noh and Yong-Chan Kim (KAIST, Korea); Sooyoung Hur (Samsung Electronics Co., Korea); Sung-Rok Yoon (Samsung Electronics, Korea); DongHyuck Park and Kuyeon Whang (Samsung Electronics Co., Korea); Dong-Jo Park and Dong-Ho Cho (Korea Advanced Institute of Science and Technology, Korea)

This paper presents 28 GHz channel measurements in vegetated areas using a directional channel sounder. The measurement campaign was conducted for two different scenarios on the campus of Korea Advanced Institute of Science and Technology (KAIST) in Daejeon, South Korea. It is found that the excess loss in vegetated areas shows a saturating trend at 28 GHz. From the measurement results, we presented 28 GHz foliage propagation models which are based on the ITU-R terrestrial model and the FITU-R-like frequency-dependent model. The average RMSE

values between the measurements and the two considered models for scenario 1 were 3.09 and 3.51 dB, respectively, while the average RMSE values for scenario 2 were 4.58 and 4.39 dB, respectively. In addition, the proposed models were compared with some existing attenuation models which are applicable at 28 GHz. These results can be used in predicting path loss through vegetated areas at 28 GHz.

11:50 ***On the Stochastic and Deterministic Behavior of mmWave Channels***

Naveed Iqbal (Huawei Technologies, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Diego Dupleich (Ilmenau University of Technology, Germany); Robert Müller (TU Ilmenau, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

A wireless channel is always composed of both deterministic and stochastic multi-path components. A high Rician K-factor increases the contribution of deterministic channel components, thereby reducing the significance of stochastic parts of a channel. This paper focus at the investigative analysis of fading depth and K-factor to analyze the deterministic behavior of a channel under a certain bandwidth and propagation setup. It has been observed that small scale fading depth asymptotically converges towards zero dB whereby K-factor increases with bandwidth. Results also show that the de-polarization of a signal increases its amplitude fading. This effect is much more significant at lower bandwidths but an increase in bandwidth reduces the difference in fade depths between polarized and depolarized signals. These observations lead to a conclusion that channel tend to be more deterministic at higher bandwidths.

12:10 ***Height-dependent Path Loss Model and Large-Scale Characteristics Analysis of 28 GHz and 38.6 GHz in Urban Micro Scenarios***

Zhimeng Zhong, Chao Li and Jianyao Zhao (Huawei Technologies Co., Ltd., P.R. China); Xiaomei Zhang (Huawei, P.R. China)

In this paper, by equipping with omni-directional antennas and high gain power amplifier in our channel sounder system, the propagation characteristics which de-embed antenna response at 28GHz and 38.6 GHz are analyzed. The base station height-dependent path loss model is derived by the channel measurement in non-line-of-sight (NLOS) urban micro outdoor scenarios. Furthermore, the path loss models at 28G and 38.6G Hz are compared with the path loss model at 3.5G. Also, the proposed path loss model is compared with 3GPP 38.900 path loss model, and it can be found that 3GPP will overestimate the system performance since the 3GPP model has lower path loss. Finally, some preliminary research on the shadowing effect of human body and vegetation are presented.

TOP

B_M01 Biological Measurements

Biomedical / Regular Session / Measurements

Oral Sessions: Room 342B

Chairs: Robin Augustine (Uppsala University, Sweden), Ana L Neves (Institut Fresnel Centre Commun de Resources en Microondes, France)

10:50 ***A Simple Approach Towards a Multi-Frequency MRI Head Phantom***

Ana L Neves (Institut Fresnel Centre Commun de Resources en Microondes, France); Lisa Leroi (Neurospin - CEA Saclay - Paris-Saclay University, France); Nicolas Cochinaire (Institut Fresnel, France); Redha Abdeddaim (Aix Marseille University, France); Pierre Sabouroux Pierre Sabouroux (Institut Fresnel, France); Alexandre Vignaud (Commissariat à l'Energie Atomique & NeuroSpin, France)

An anatomically realistic human head phantom was elaborated for different Larmor frequencies, which allows rapid quantification of B1+ of MRIs of different magnetic fields. The permittivity ε' and conductivity σ of sucrose/salt/agar aqueous solutions of varying concentration was determined; a solution with these components and having the adequate concentration to obtain the brain's dielectric properties at 3 T, 7T and 11.7T was manufactured. An anthropomorphic polymeric skull was filled with this mixture. To check the behavior of this phantom in a MRI configuration, both numerical and experimental validations were done: a B1+ field distribution inside the phantom was calculated with CST Microwave Studio inside a birdcage coil at 7T; the same mapping was assessed in a 7T MRI. This work has shown the possibility of manufacturing a head phantom with accessible and cheap components for MRI evaluation, having an adequate B1+ field distribution and the dielectric properties of the brain

11:10 ***Signal Analysis and Phantom Experiments for a Miniaturized Time-Domain Microwave Breast Health Monitoring Device***

Karim El Hallaoui, Adam Santorelli, Milica Popović and Mark Coates (McGill University, Canada)

This work presents a miniaturized system for performing time-domain microwave scans to detect malignancies within breast tissue. The proposed changes miniaturize components of the system designed by the McGill Breast Cancer Detection Group. The aim of this paper is to present the implementation of the Adafruit Si5351 Clock Generator and the Furaxa Pulser as an alternative to the currently used large table-top and expensive Tektronix gigaBERT 1400 Clock Generator and Picosecond Model 3600 Impulse Generator respectively. The miniaturized and cost-effective components can be integrated to achieve a comfortable and compact medical imaging device. This paper validates the proposed changes to the system by comparing their signals at the relevant stages of the system. Moreover, a dataset is collected with the proposed system changes using realistic breast phantoms across a five day period.

11:30 ***Link Budget Study and Realization of Time-Domain Measurement Setup for***

Implantable Antennas

Joao Felicio (Instituto de Telecomunicações/Instituto Superior Técnico, Portugal); Carlos A. Fernandes (Instituto de Telecomunicacoes, Instituto Superior Tecnico, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE-IUL, Portugal)

This paper extends the study of a previously proposed wideband implantable antenna to be embedded at superficial level in the muscle. The antenna covers the frequency band between 1.4 GHz and 4.2 GHz and is compatible with integration with an energy scavenging circuit. We assess its performance through a time-domain setup and emphasize some aspects regarding the measurements. Finally, we perform a complete study of the link budget between the passive implant and the external reader that supplies the energy for powering the implant assuming European regulation.

11:50 ***Microwave Sensors for New Approach in Monitoring Hip Fracture Healing***

Mauricio D Perez (National Technical University, Argentina); Syaiful Redzwan Mohd Shah and Jacob Velander (Uppsala University, Sweden); Marco Raaben (University Medical Center Utrecht, The Netherlands); Noor Badariah Asan (Uppsala University, Sweden); Taco Blokhuis (University Medical Center Maastricht, The Netherlands); Robin Augustine (Uppsala University, Sweden)

Cyber-Physical System (CPS) applications in lower-extremity bony-fracture rehabilitation systems require real-time biophysical data. Emerging and interesting solutions are microwave approaches that provides good contrast between hard and soft tissues and between local anomalies inside tissues. Preliminarily some contacting non-invasive planar methods have been investigated in their feasibility of detecting human tissues variations with promising results. In this work we introduce two new microwave planar sensors for a new approach of hip fracture healing follow-up tool. They are designed for improved resolution and penetration at frequencies between 1 to 3 GHz in detecting variations in bone, muscle or fat tissues that are expected during a rehabilitation process. The resonant devices are optimized using Frequency Domain Reflectometry and CST® environment and validated using clinical trials with volunteers. The new approach is validated using clinical trials with volunteers and patients. These outcomes emphasize the feasibility of devising systems for hip after-fracture rehabilitation.

12:10 ***Microfluidic Planar Resonator Sensor with Highly Precise Measurement for Microwave Applications***

Amyrul Azuan Mohd Bahar, Zahriladha Zakaria, Siti Rosmaniza Ab Rashid and Azmi Awang Md Isa (Universiti Teknikal Malaysia Melaka, Malaysia); Rammah A. Alahnomi (Universiti Teknikal Malaysia Melaka (UTeM), Malaysia); Yosza Dasril (Universiti Teknikal Malaysia Melaka, Malaysia)

In this paper, a microfluidic planar resonator sensor is proposed to identify the unknown permittivity of liquid solvents. The frequency response from known permittivity of solvents is critically analyzed using polynomial plotting graphs. Meanwhile, high sensitivity detection sensor with more than 400 quality factor and 0.27% maximum discrepancy errors is observed. The proposed planar resonator was designed, fabricated, and validated. Both simulated and measured results are in good agreement and it is suitable for pharmaceutical and biomedical applications.

TOP

L_P01 Localization & Ranging

Localization & Connected Objects / Regular Session / Propagation

Oral Sessions: Room 352B

Chairs: Wout Joseph (Ghent University/IMEC, Belgium), Yang Miao (Catholique Universite de Louvain, Belgium)

10:50 ***A Propagation Modeling Approach to Urban Navigation***

Zhuangzhuang Dai, Robert J Watson and Peter Shepherd (University of Bath, United Kingdom)

The performance of GPS in densely built urban areas is greatly undermined due to multipath propagation. Therefore, we propose a propagation model which is used to obtain 'location fingerprints' with the aid of modern computers thanks to their growing processing power. At the heart of the technique is the use of a ray-launching model from which a database is generated containing propagation parameters such as received signal strength, time of arrival and angle of arrival as a function of source and receiver location. These are then mapped with physical locations using an artificial neural network. Besides, a sequence based tracking tool is proposed to assist navigation with minimal communication required between mobile device and database. This paper details the generation of a database for real world geometries read from OpenStreetMap and the development of a localisation algorithm.

11:10 ***Efficient Time Domain HF Geolocation Using Multiple Distributed Receivers***

Ankit Jain, Pascal Pagani and Rolland Fleury (Telecom Bretagne, France); Michel Ney (TELECOM Bretagne Institute, France); Patrice Pajusco (TELECOM Bretagne, France)

This paper explores the effect of increasing number of receivers to evaluate the geographic location of the High Frequency (HF) transmitters for distances in the radius of 2000 km. In the case of HF propagation over long distances, signals propagate using skywaves and are reflected back to the earth from the ionosphere. The Quasi-Parabolic (QP) model of the ionosphere provides analytic equations for ray path parameters through which the signal travel time is obtained. The position of the transmitter is found using time domain HF geolocation method namely Time Difference of Arrival (TDoA). An analysis of the QP model of the ionosphere is provided and limits of the model are emphasized. The geolocation algorithm for TDoA along with its mathematical equation is explained. Simulation results demonstrate that increasing the number of receivers leads to a significant improvement in the geolocation accuracy.

11:30 ***Radio Frequency UAV Attitude Estimation Using Direction of Arrival and Polarization***

Attiya Mahmood (Brigham Young University, USA); Jon Wallace (Lafayette College, USA); Michael Jensen (Brigham Young University, USA)

This paper proposes a new algorithm for estimating the relative attitude between two unmanned aerial vehicles based on multiple-input multiple-output radio frequency transmissions between the two aircraft. The method is able to estimate all three Euler angles required to describe the relative attitude, in contrast to prior methods that place severe limits on what can be estimated. Initial simulations based on the algorithm reveal that the estimation errors are relatively small even for moderate signal-to-noise ratios.

11:50 ***Long Reading Range Chipless RFID System Based on Reflectarray Antennas***

Maher Khaliel (Universität Duisburg-Essen, Germany); Ahmed Elawamry (University of Duisburg-Essen, Germany); Abdelfattah Fawky (University of Duisburg Essen, Germany); Thomas Kaiser (Universität Duisburg-Essen, Germany)

This work proposes the utilization of the Reflect Array (RA) antenna in the reader of the Frequency Coded (FC) chipless RFID systems aiming at increasing the reading range, minimizing the environmental reflections and acquiring a lot of novel capabilities that can not be provided by the conventional antenna systems. The presented RA antenna operates over UWB range of frequencies from 4 to 6 GHz fulfilling the requirements of the FC chipless RFID systems. Furthermore, the RA antenna beam is 4 times narrower than the feeder beam and thus 6 dB higher in gain with -10 dB SLL. Therefore, this developed UWB RA antenna is successfully integrated with the FC chipless RFID tags and a reading range of 1 m is attained. To the best of the author knowledge, this is the highest reading range achieved in the FC chipless RFID systems, considering real-world indoor environment and software defined radio reader.

12:10 ***Improved Energy Detection Receiver for Ranging in IEEE 802.15.4a Standard***

Abdelmadjid Maali (Ecole Militaire Polytechnique, BEB, Alger, Algeria); Geneviève B. Baudoin (ESIEE, France); Mesloub Ammar (Ecole Militaire Polytechnique)

In this paper, we propose a novel energy detection (ED) receiver architecture combined with time-of-arrival (TOA) estimation algorithm, compliant to the IEEE 802.15.4a standard. The architecture is based on double overlapping integrators and a sliding correlator. It exploits a series of ternary preamble sequences with perfect autocorrelation property. This property ensures coding gain which allows an accurate estimation of power delay profile (PDP). To improve TOA estimation, the interpolation of PDP samples is proposed and the architecture is validated by using an ultra-wideband (UWB) signals measurements platform. These measurements are carried out in line-of-sight (LOS) multipath environment. The experimental results show that the ranging performances obtained by the proposed architecture are higher than those obtained by the conventional architecture based on a single-integrator.

TOP

B_P02 Body-Centric Propagation

Biomedical / Regular Session / Propagation

Oral Sessions: Room 353

Chairs: Luca Petrillo (Université Libre de Bruxelles, Belgium), Guido Valerio (Sorbonne Universités UPMC, France)

10:50 ***Power Coupling for Conceptual Antennas in Medical Implant Applications***

Ali Khaleghi (Oslo University Hospital, Norway); Ilangko Balasingham (Norwegian University of Science & Technology & Oslo University Hospital, Norway)

In this paper, we study two conceptual antennas of loop and dipole geometries for power coupling in medical implant applications. The coupling between the on-body mounted antenna and the implant antenna is the study scenarios. A sample muscle tissue with the implant antenna of size 40 mm in the depth of 50 mm and wide frequency range of 200-3000 MHz are used for computations. Frequency dependent electromagnetic characteristics of the biological tissue are considered. It is shown, that the coupling between a pair of the loop antennas surpasses the coupling in the other combinations of the loop and dipole for the frequencies below 800 MHz. Also, the on-body loop antenna induces less specific absorption rate (SAR) than the dipole that permits more power injection and thus higher energy transfer to the implant antenna. Furthermore, the size effects of the loop antenna on the power coupling are reported.

11:10 ***Human Body Communication Channel Modeling Using Vector Network Analyzer Measurement***

Luca Petrillo (Université Libre de Bruxelles, Belgium); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); Hugues Libotte (Université Libre de Bruxelles, Belgium); Aziz Benlarbi-Delaï (Sorbonne Universités, UPMC Paris 06, France); François Horlin (Université Libre de Bruxelles, Belgium); Philippe De Doncker (ULB, Belgium)

Several studies have examined the propagation losses of the Human Body Communication (HBC) channel. However, a general agreement has not be found yet. In this paper, the complete S-matrix of the HBC channel is measured on an human subject using two kinds of electrode devices. The data is integrated in a lumped element model, which allows to take into account for the capacitive return path of realistic battery operated transmitter and receiver. Results, shown as power gain curves between 10 MHz and 150 MHz, exhibit a band pass profile, with cut-off frequency depending on the kind of electrode devices. A model is obtained by vector fitting of the equivalent Z-matrix of the measured HBC channel.

11:30 ***Implementation Methodology of Handshaking Communication Using Wearable Near-Field Coupling Transceivers***

Ryo Takeuchi and Shin Hasegawa (Kyoto Institute of Technology, Japan); Yuichi Kado (Kyoto Institute of Technology & Graduate School of Science and Technology, Japan); Daiki Ayuzawa and Mitsuru Shinagawa (Hosei University, Japan); Kyoji Ohashi and Daisuke Saito (Nippon Signal Co., Ltd., Japan)

Near-field coupling communication (NFCC) is a communication technology that treats the surface of the human body as a transmission path by using a carrier frequency below 10 MHz. Because the radiation signal to a space is suppressed in NFCC, humans wearing an NFCC transceiver (TRX) can exchange personal information through handshaking without having to worry about information leakage. To establish stable personal information exchange, handshaking communication needs to satisfy two requirements relating to the signal propagation loss difference between standing and handshaking postures and the S/N ratio in the handshaking posture. From the equivalent circuit of the handshaking communication, we present the position of the TRXs that satisfy the two requirements. Experimental results revealed that the two requirements are satisfied when NFCC TRXs are inserted into the soles of shoes. As a result, we demonstrated that handshaking communication can be implemented by inserting TRXs into the soles of shoes.

11:50 ***Wavelet-Based Analysis of 60 GHz Doppler Radar for Non-stationary Vital Sign Monitoring***

Ting Zhang (Sorbonne Universités, UPMC Paris 06, France); Guido Valerio (Sorbonne Universités UPMC, France); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); Mircea Dan Istrate (UTC, France)

We propose here a Doppler-radar implementation at 60 GHz for contactless monitoring of vital signs (respiration and heartbeat). In order to provide a real-time detection of non-stationary vital signs and critical events, an estimation technique is here used by means of a wavelet transform of the received signals. Moreover, the amplitudes of the relevant vital movements can be deduced by the wavelet transform so as to distinguish the useful signal from noises and non-desired movements.

12:10 ***An Application of Universal Polynomial Chaos Expansion to Numerical Stochastic Simulations of an UWB EM Wave Propagation***

Piotr Górniak (Poznań University of Technology, Poland)

In the paper a new form of universal polynomial chaos expansion, which was introduced in [1], is applied to numerical stochastic simulations o ultra-wideband (UWB) electromagnetic wave propagation. It is assumed that stochastic parameters of a propagation scenario follow a Gauss distribution. The coefficients of an expansion are analytical functions of a mean and a standard deviation a stochastic variable (scenario parameter), which makes an expansion universal. The necessary initial coefficients have to be calculated numerically only once for a freely chosen values of stochastic variable parameters. Then these initial coefficients are used to calculate analytically the universal coefficient

TOP

Sp_A05 Antenna-System for Space Applications

Space / Regular Session / Antennas

Oral Sessions: Room 362/363

Chairs: Cecilia Cappellin (TICRA, Denmark), Chi-Chih Chen (The Ohio State University, USA)

10:50 ***A 6-40 GHz CubeSAT Antenna System***

Jiukun Che (the Ohio State University, USA); Chi-Chih Chen and Joel T. Johnson (The Ohio State University, USA)

This paper presents a high-gain 6-40 GHz circularly polarized antenna system designed for a 6U CubeSAT mission for monitoring RF emission from earth. The antenna system consists of three quasi-tapered helical antenna elements, operating at 6-11 GHz, 11-22 GHz and 21-40 GHz, respectively. Each antenna element is designed to produce an end-fire beam with its helical diameter varying along its axis to achieve a linearly increasing gain from 12 dBic gain at 6 GHz to 20 dBic at 40 GHz. The close proximity of the antennas causes strong mutual coupling and pattern distortion. This problem is alleviated by carefully arranging the antenna positions, the utilization of different circular polarization (CP) handedness, as well as loading of the radome.

11:10 ***The Observable Field for Antennas in Reception***

Andrea Neto, Nuria LLombart and Arturo Fiorellini Bernardis (Delft University of Technology, The Netherlands); Angelo Freni (University of Florence, Italy)

In this paper we provide a simple and accurate physical picture of the antenna reception mechanism. Specifically we introduce the concept of the observable field. This is the portion of the incident field that can be received by an ideal antenna located in a given region of space. Thus this field defines the available power, and provides clear guidelines into the design of such ideal antenna. The observable field is composed by two complementary inward and outward propagating spherical waves whose amplitude can be calculated, without introducing spherical wave vector modes, simply via the equivalence theorem. This methodology is derived here for a single plane wave but it can be easily extended to multiple coherent plane waves.

11:30 ***Full-Wave and Multi-GTD Analysis of the Ice Cloud Imager for MetOp-SG***

Jakob Rosenkrantz de Lasson, Cecilia Cappellin and Per Nielsen (TICRA, Denmark); David Marote Alvarez, Marc Bergada and Raquel Gonzalez (Airbus/CASA, Spain); Peter de Maagt (European Space Agency, The Netherlands)

We report an RF study at 50 GHz of the Ice Cloud Imager, consisting of a parabolic reflector inside a semi-closed sun shield, as obtained with full-wave method of moments (MoM) and the asymptotic high-frequency multi-

geometrical theory of diffraction (Multi-GTD) method. The Multi-GTD results accurately reproduce details of the main beam and sidelobes originating from focusing, but fail to predict other parts of the pattern that are due to a large number of scattering events inside the semi-closed sun shield. MoM results at the half and double frequency (25 and 100 GHz) show that the parts of the pattern that are not well described by Multi-GTD, but still within the dynamic MoM range, remain at the same overall level as the frequency is varied. Thus, when analyzing at higher frequencies of interest (> 183 GHz), a complementary MoM and Multi-GTD approach can be adopted to predict the radiation pattern.

11:50 ***A Dual-Band Wide-Angle Scanning Phased Array Antenna in K/Ka Bands for Satellite-on-the-Move Applications***

Kamil Yavuz Kapusuz (Ghent University, Belgium); Ozlem Aydin Civi (Middle East Technical University, Turkey); Alexander Yarovoy (TU Delft, The Netherlands)

This paper presents the design of a dual-band cavity-backed phased array antenna with wide-angle scanning capability in K/Ka bands for the geostationary (GSO)-fixed satellite service (FSS). A planar radiating aperture-fed microstrip antenna is used to guarantee the low profile of the proposed element. To reduce the losses and mutual coupling, a novel antenna element similar to the cavity-backed Strip-Slot-Air-Inverted Patch (SSAIP) is proposed as an element of designed array of 81 elements. Wide-angle scanning up to 60o is achieved at both frequency bands of the operation.

12:10 ***A TM01 to TE11 Mode Converter Designed with Semicircular Waveguide Sections***

Ashish Chittora (Pandit Deendayal Petroleum University, India); Sandeep Singh (Bhabha Atomic Research Centre, India); Archana Sharma (BARC, India); Jayanta Mukherjee (Indian Institute of technology Bombay)

A novel TM01 to TE11 mode converter with aligned ports, wide bandwidth and high conversion efficiency is proposed. Mode conversion is performed with a circular waveguide partitioned into two semicircular sections with different path length. Lower semicircular section has a cosine profile to provide a path difference of lambda_g/2 for the mode conversion. Mode converter was designed and simulated at 3 GHz operating frequency. Electric field calculation shows that the mode converter can handle up to 3 GW high power microwave pulse signal. The mode converter was fabricated and the mode conversion was verified experimentally, by measuring far-field radiation pattern of the output mode. The proposed mode converter has a symmetric structure and has the advantage of aligned ports and wide bandwidth.

Wednesday, March 22, 13:30 - 15:00

Poster_03

TOP

Localization & Connected Objects / Regular Session / Antennas

Room: Poster Sessions: Corridor Neuilly

Chairs: Marjorie Grzeskowiak (University of Paris-Est Marne-la-Vallée, France), Patrick McEvoy (Dublin Institute of Technology, Ireland)

Analysis of Antennas for Underwater Applications

Andrea Massaccesi and Paola Pirinoli (Politecnico di Torino, Italy)

Underwater Communication has a wide range of applications. In the case of a short-range communication system, the use of electromagnetic waves has been recently proposed as an alternative to the mostly used acoustic waves. The design of the antennas to be used for underwater communication is strongly influenced by the electromagnetic properties of the water and therefore, after its design but before its experimental characterization, it is necessary to perform an accurate numerical analysis of its behavior. As a proof-of concept, here the results obtained with the full-wave numerical analysis of antennas designed for an underwater communication system between scuba divers are illustrated, considering two types of realistic water environment: seawater and freshwater.

Design of a Dual-mode Meander-line Loaded Monopole Antenna with Characteristic Mode Theory

Mohammad Bagheriasl (University of Tehran, Iran); Karim Mohammadpour-Aghdam (University of Tehran & KUL, Iran); Reza Faraji-Dana (Center of Excellence on Applied Electromagnetic Systems, Iran)

The authors have previously proposed a tunable meander-line loaded monopole antenna. In this paper, the antenna structure proposed by the authors is modified to operate as a dual-mode antenna with very good frequency bandwidth. Characteristic mode analysis is performed on the modified antenna structure to investigate the suitability of the novel structure for dual-mode operation. Then, a dual-mode antenna is designed and the performance of such antenna is investigated.

Equivalent Input and Output Impedances in HF RFID System Including Resonator

Benamara Megdouda (University Paris Est Marne La Vallee, France); Marjorie Grzeskowiak (University of Paris-Est Marne-la-Vallée, France); Antoine M Diet (Paris Saclay - Université Paris Sud (GeePs UMR 8507 - IUT de Cachan), France); Gaelle Lissorgues (ESIEE, France); Yann Le Bihan (LGEP UMR 8507, France)

High Frequency Radio Frequency Identification (HF RFID) system based on Magnetically Coupled Reader Resonator Coils (MCRRC) is reported. The proposed system consists of reader antenna including small resonant coil operating by magnetic coupling with the tag coil. In the proposed system, the reader and tag impedances are modified. The

equivalent electrical model is used to express the equivalent impedance matrix and used to express the equivalent input and output impedances of the system. The formulas are confirmed by comparison between High Frequency Structure Simulator (HFSS) results and measures.

Coaxially Distributed Diameter sub-Coil Twisted Loop Antenna in HF RFID

Marjorie Grzeskowiak (University of Paris-Est Marne-la-Vallée, France); Antoine M Diet (Paris Saclay - Université Paris Sud (GeePs UMR 8507 - IUT de Cachan), France); Benamara Megdouda (University Paris Est Marne La Vallee, France); Stephane Protat (University of Paris-Est Marne-la-Vallée, France); Christophe Conessa (GeePs/CentraleSupélec/CNRS, France); Marc Biancheri-Astier (Paris Saclay - Université Paris Sud (GeePs UMR 8507 - IUT de Cachan), France); Francisco Alves and Yann Le Bihan (GEEPS, France); Gaelle Lissorgues (ESIEE, France)

This paper proposes an HF (High Frequency) transmitting coil less sensitive to the angular and position misalignments of the small receiving coil. The DDC (Distributed Diameter Coil) shape and TLA (Twisted Loop Antenna) allow respectively minimizing the disturbance of the magnetic link due to the lateral misalignment and the relative tilting direction of the transmitting coil to the receiving coil. The magnetic coupling link obtained from DDC TLA coils is illustrated by comparison with conventional TLA in the case of HF RFID.

Low-Cost Surrogate Modeling for Rapid Design Optimization of Antenna Structures

Slawomir Koziel (Reykjavik University, Iceland); Adrian Bekasiewicz (Gdansk University of Technology, Poland)

Availability of fast yet reliable replacement models is essential to reduce the computational cost of antenna design process. Unfortunately, conventional approximation (or data-driven) modeling is not well suited for modeling of highly nonlinear responses of antenna structures, especially for larger number of geometry parameters. In this work, we propose a novel approach where the region of surrogate model validity is restricted to a manifold spanned by several reference designs corresponding to antenna optimized for various operating frequencies and dielectric permittivity of the substrate material. This allows us to focus the modeling process in the region that only contains designs that are close-to-optimum from the point of view of the aforementioned operating/material criteria. Rigorous analytical formulation of the technique is supported by a case study of a ring slot antenna. Considerable reduction of the number of training points compared to conventional modeling methods is demonstrated.

Statistical Modeling of the Reflection Coefficient of Deformable Antennas

Jinxin Du (Télécom ParisTech & Institut Mines−Télécom, France); Christophe Roblin (Telecom ParisTech & LTCI - Institut Mines-Télécom, France)

A modeling methodology is proposed for characterizing the reflection coefficient S11(f) of narrow band antennas undergoing random disturbances. Firstly, identification techniques are used to get a parsimonious representation of the S11; then the Polynomial Chaos Expansion (PCE) method is used to characterize quantitatively the influence of random disturbances on the compressed S11. The derived S11 model can be used as efficient surrogate for statistical analysis of antennas' frequency behavior. We have applied the proposed methodology to two narrow band antennas - a deformable dipole and a textile patch - in order to demonstrate its performance. Models with good accuracy have been derived for both cases.

A High-Power Wide Beamwidth Circularly Polarized Antenna with Lightning Protection

Bo Wang and William S. W. Cheung (The University of Hong Kong, Hong Kong); Weiyun Wang (Fenghuo Nuoxin Science&Technology Co., P.R. China); Min Li and Ti Yuk (The University of Hong Kong, Hong Kong)

A high-power wide beamwidth circularly polarized (CP) antenna with lightning protection is presented. The antenna is designed to operate at 1.41 GHz with a wide beamwidth for airport uses. It consists of four helix antenna elements forming a quadrifilar-helix antenna (QHA), a strip-line feeding network and a lightning rod for lightning protection. The QHA is fed using a high-power feeding network with sequential phase rotation of 90o. The lightning rod is installed at the center of the ground plane on the base of the antenna. Simulation is used to design and study the antenna which is also fabricated with housing for measurement. Simulation and measured results agree well. Results show that the QHA antenna has a hemispherical radiation pattern with a beamwidth of 100° and a CP beamwidth of 109° in elevation.

A Broadband and Wide Beamwidth Dual Circularly Polarized Antenna Using Crossed Bent Dipoles

Bo Wang and William S. W. Cheung (The University of Hong Kong, Hong Kong); Weiyun Wang (Fenghuo Nuoxin Science&Technology Co., P.R. China); Min Li and Ti Yuk (The University of Hong Kong, Hong Kong)

A broadband and wide-beamwidth dual circularly polarized (CP) antenna is presented in this paper. The antenna consists of two bent dipoles placed in a crossed shape. The dipoles are individually fed with signals with quadrature phases from a 3-dB hybrid coupler chip. A metal cavity serving as a reflector is used to produce a unidirectional radiation pattern. Measurements show that the antenna has an impedance bandwidth of 66.2% (0.98-1.95 GHz) for |S11|<-10 dB, an axial-ratio bandwidth (ARBW) of 51.4% (1.03-1.75 GHz) for AR<3 dB, and a very wide AR beamwidth of over 162° with a maximum AR beamwidth of 260°.

Integrated Rectifying Circuit and Antenna Design with Harmonic Rejection for RF Energy Harvesting

Sharif Ahmed (Universiti Teknikal Malaysia Melaka & UTeM, Malaysia); Zahriladha Zakaria and Mohd Nor Husain (Universiti Teknikal Malaysia Melaka, Malaysia); Ammar Alhegazi (University Technical Malaysia Melaka (UTeM), Malaysia)

This paper presents a rectifying antenna (rectenna) which operates at 2.45 GHz. The antenna consists of two-layer low-cost FR-4 substrates separated by an air gap to enhance the gain. The harmonic rejection property is

embedded within the antenna design to eliminate the use of harmonic rejection filter (HRF) between the antenna and rectifier, which reduces the cost and size of the rectenna. The rectifying circuit consists of two stages combined by a power combiner to maximize the output voltage. A fast switching Schottky diode of HSMS 286B is used for rectification process. The measured RF-DC conversion efficiency of the proposed rectenna is 78.7 % at an input power of 20 dBm and load impedance of 4 KΩ. The proposed rectenna can provide high RF-DC conversion efficiency which is suitable for RF energy harvesting applications.

A Technique to Narrow down Radiation Patterns of Broad Beam Antenna Operationally and Its Application to Security Gate to Prevent Shoplifting Based on Monopulse System

Tomoki Sakogawa, Katsuyoshi Aoki and Futoshi Kuroki (National Institute of Technology, Kure College, Japan)

In this paper, a technique to narrow down the radiation patterns of the antenna operationally was proposed while keeping antenna size to be small. The main emphasis was placed on the analog signal processing using the monopulse system having antennas with broad radiation patterns. The sensitivity of arrival angle detection form the RF-tags was newly defined and it was evaluated using the microstrip patch antenna pair with a half power beam width of 150 deg as a function of the antenna pair distance. From the numerical and experimental investigations, it was obvious that the antenna pair distance from fortieth part to tenth part of a free space wavelength guaranteed the narrow beam operation to be less than the range of the arrival angle of 10 deg although the half power beam width of the microstrip path antenna was 150 deg.

Ultra-Wideband Linear Polarization Converters Based on Pixelated Reflecting Metasurfaces

Michele Borgese (Università di Pisa, Italy); Filippo Costa and Simone Genovesi (University of Pisa, Italy); Agostino Monorchio (University of Pisa & CNIT, Italy)

An ultra-wideband linear polarization converting metasurface is presented. The polarizer is based on a periodic arrangement of metallic elements printed on a grounded dielectric substrate. The element geometry of the metasurface is optimized with a genetic algorithm by discretizing the unit cell in a 16x16 pixel matrix. This polarization converter is able to work from 7.03 GHz to 29.01 GHz (121% of bandwidth) with a cross polar reflection coefficient greater than -2 dB. A refinement algorithm is also applied to the optimized cell in order to further extend the operative bandwidth and at the same time remove unnecessary pixels. Finally, the bandwidth is extended up to 129%. The unit cell periodicity is 4.6mm and the thickness of the low loss substrate is 3mm.

A New Circularly Polarized Antenna for GNSS Applications

Umniyyah Ulfa Hussine, Yi Huang and Chaoyun Song (University of Liverpool, United Kingdom)

A new and circularly polarized (CP) antenna is proposed for global navigation satellite systems (GNSS) applications. The antenna employs a single feed and two orthogonally elliptical printed dipoles. The dipoles are crossed through a 90° phase delay line of a vacant-quarter printed ring to achieve CP radiation. In order to achieve broad beamwidth, four metallic cylinders are introduced. The proposed antenna has achieved a bandwidth of about 43% from 1.08 to 1.69 GHz for S11 < -10 dB. Meanwhile, the CP bandwidth is from 1.55 to 1.63 GHz (L1) and 1.12 to 1.26 GHz (L2, L5) for axial ratio < 3 dB. Additionally, the antenna yields right-hand circular polarization (RHCP) and high antenna efficiency over a wide frequency band. The simulated results have shown that the proposed antenna is a good candidate for GNSS applications.

A Compact Wideband 4-Port Circularly Polarized Dielectric Resonator Antenna

Slobodan Jović (Defence R&D Canada, Canada); Michel Clénet (Defence Research and Development Canada, Canada); Yahia Antar (Royal Military College of Canada, Canada)

We present in this paper a novel wideband circularly polarized dielectric resonator antenna (DRA) covering the complete Global Navigation Satellite System (GNSS) frequency band (1150-1620 MHz). This antenna, considering its simplicity, provides excellent performance in terms of gain, axial ratio and beamwidth across the entire operating bandwidth while being relatively low profile and with a design permitting insertion of the RF front-end right below the antenna ground plane. Even though GNSS is the targeted application in this paper, this antenna can be used for other purposes, like in MIMO systems or as a polarization discriminator.

Status Update on the System Validation of APERTIF, the Phased Array Feed System for the Westerbork Synthesis Radio Telescope

Boudewijn Hut (ASTRON Netherlands Institute for Radio Astronomy, The Netherlands); Raymond van den Brink and Wim A. van Cappellen (ASTRON, The Netherlands)

Phased Array Feed (PAF) systems are installed on the Westerbork Dishes, allowing new type of science for the astronomical community. All 12 dishes are equipped with the hardware and the central systems are in place too. The PAFs need a dedicated calibration scheme in order to satisfy stability requirements. The verification process has finished for most system elements, and the first validation test passed with flying colors.

Mechanically Reconfigurable Waveguide-Slot Single Element Using Tuning Screws

Pablo Sanchez-Olivares and Jose Luis Masa-Campos (Universidad Autonoma de Madrid, Spain); Javier Hernandez-Ortega (Universidad Autonoma de Madrid)

A mechanically reconfigurable waveguide-slot single radiating element is presented. The tuning mechanism consists on three metallic screws introduced through the bottom wall of the feeding waveguide. The insertion length of the tuning screws and the distance to the slot are used to control the radiated signal as well as to maintain a good input matching response. Several prototypes with different slot lengths have been manufactured to experimentally validate the reconfigurable performance. The proposed triple tuning screw waveguide-slot radiator provides a low cost and simple mechanism to conform a reconfigurable array antenna

Implementation of 4 x 4 Stacked Patch Array with Corporate Feeding Network for Ku-band Applications

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

In this work, the experimental implementation of a 4 x 4 stacked-patch array with linear polarization and a corporate feeding network for Ku-band is exposed. The feeding network is split into two levels, with an initial power distribution in Substrate Integrated Waveguide and a second distribution in microstrip technology. The experimental results show a matching coefficient better than -10 dB in a 15.9% bandwidth. In addition, the measured gain attains 16.8 dBi, 0.8 dB below the simulated gain, while radiation efficiency is 66 %. The structure is validated for higher-gain arrays, and hence designs of 8 x 8 and 16 x 16 radiating elements are also proposed and the simulated results presented. Therefore, antennas with several gain values are available in order to suit the different elements of the communication system, such as the end user and the base station.

Broadband Circularly Polarized NFRP Antenna Using Crossed Dipole Driver

Son Xuat Ta and Ikmo Park (Ajou University, Korea); Richard W. Ziolkowski (University of Arizona, USA)

This paper presents a planar, broadband, electrically-small, circularly polarized (CP), near field resonant parasitic (NFRP) antenna fed by a crossed dipole driver. The driven and parasitic elements are printed on two separate thin substrates, which are stacked together with no air-gap to achieve the compact planar configuration. The technique of introducing meander lines and arrowhead-shaped endings in both elements is utilized to achieve the electrically small size. The parasitic and driven elements are designed to produce CP radiation at different frequency bands, which are then combined to obtain the broadband characteristic. The final design, whose driven and NFRP elements are implemented on two substrates of the same size, i.e., 35 mm × 35 mm × 0.508 mm, yields a measured |S11| < −10-dB bandwidth of 218 MHz (1.491-1.709 GHz) and 3-dB AR bandwidth of 145 MHz (1.490-1.635 GHz). Additionally, the antenna produces bi-directional radiation and has a high radiation efficiency.

A Highly Miniaturized Loop Excited Quasi-YagiAntenna with High Front-to-Back Ratio

Syed Jehangir (King Fahd University of Petroleum and Minerals, Saudi Arabia); Mohammad S. Sharawi (King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia)

A multi-band Quasi-Yagi antenna based on loop excitation is presented with 68% miniaturization, which is achieved using loop meandering and a novel defected ground structure (DGS), targeting the 2 GHz band. It has a minimum measured -6 dB bandwidth of 249 MHz (0.780-1.029 GHz) in the lower band and 286 MHz (1.932-2.218 GHz) in the upper band covering several LTE bands. The proposed antenna ensures very good Yagi-Uda performance in terms of front-to-back ratio (FBR) and cross-polarization. It has a very high FBR of more than 20 dB with a ground plane width of only 7mm, and has very low cross polarization of -29.3 dB. The gain of the proposed antenna is around 6 dBi, directivity is 8.2 dB, and efficiency is 73%. The size of the miniaturized model is 60 × 50 × 0.8 mm3.

Design of Dual-band Compact Ceramic Chip Antenna for Terminal Applications

Yuan Yao and Haiyang Yu (Beijing University of Posts and Telecommunications, P.R. China); Junsheng Yu (University of Electronic Science and Technology of China, P.R. China); Xiaodong Chen (Queen Mary University of London, United Kingdom)

In this paper, a novel dual band compact antenna based on planar inverted-F antenna (PIFA), ceramic substrate and interdigital coupled structure are proposed. It has compact size with the dimensions of 10.2*3*2.5mm3. The operating mechanisms are illustrated and the study on the key dimension parameters is given. Both the simulation and measurement results are shown to verify the good performance of the antennas. The antenna can operate at both 1.575GHz and 2.45GHz and offers a maximum total gain about 3.21dBi and 3.5dBi respectively. It is suitable for multifunctional applications in terminals.

Cavity-Backed Slot Antenna for Thin Wireless Portable Devices

Rohit Chandra (Sunway Communication AB, Sweden)

A conventional cavity-backed slot antenna (CBSA), excited by a probe, requires a large space due to the size of the resonant cavity especially at lower frequencies. An alternative CBSA antenna can be designed by using a compact non-resonant cavity where the slots are excited. This paper presents such a CBSA for dual-band (2.4 GHz and 5 GHz) Wi-Fi applications for an ultra-thin portable wireless device (like tablet or laptop) with the thickness in the range of 4 mm to 5 mm. The presented antenna is L-shaped and can be placed at the corner of the device. The antenna meets the efficiency requirement that is greater than -7 dB in the 2.4 GHz band and greater than -6 dB in the 5 GHz band. Hence, the presented antenna is a suitable candidate of Bluetooth/Wi-Fi antenna for slim laptops or tablets

Use of a Dielectric Resonator Antenna to Reduce Hand Effect in a Miniature IoT Device

Kaoutar Allabouche (FST Fes, Morocco); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Leonardo Lizzi (Université Côte d'Azur, CNRS, LEAT, France); Jean-Marc Ribero (Université de Nice Sophia Antipolis, France); Mohammed Jorio (FST Fes, Morocco); Najiba El Amrani El Idrissi (faculté des sciences technique de Fés.maroc, Morocco)

In this work, we compare two different antenna topologies integrated in a miniature IoT device working at 900 MHz: Inverted F Antenna (IFA) and Dielectric Resonator Antenna (DRA). This type of handheld device can be strongly impacted by human body effect, consequently we study the radiation performance of the two structures close to a human hand. Electromagnetic simulations show for the IFA a 15 dB decrease of the total efficiency with hand influence, while the DRA total efficiency is only decreased by 2 dB in the same situation.

A Multiband On-Chip Antenna for 94 and 140 GHz Applications

M. Saad Khan and Farooq A. Tahir (National University of Sciences and Technology, Pakistan); Hammad Cheema (School of Elect. Engineering and Comp. Science, National Uni. of Science & Technology, Pakistan)

A bowtie slot on-chip antenna (OCA), exhibiting multiband operation at 94 and 140 GHz is presented. The first of its kind on-chip multiband operation is achieved by adding parasitic loading elements in the slots. The bond-pads along with a shunt-stub, form the impedance matching network of the antenna. Designed in IHP 130nm BiCMOS process, the simulated gain of the proposed antenna is -4.09dBi and -4.76 dBi at 94 GHz and 140 GHz respectively while occupying 494366650 m3. The small on-chip dimensions at mm-wave frequencies along with the presented multiband operation can be extremely useful for supporting multiple upcoming wireless communication

applications.

Electromagnetic Feasibility of a Passive Wireless Sensor Network for Temperature Mapping Inside a Shielded Enclosure

Sergio López-Soriano (Universitat Autònoma de Barcelona, Spain); Ivan Spassovsky (ENEA, Italy); Josep Parrón (Universitat Autònoma de Barcelona, Spain); Gaetano Marrocco (University of Rome "Tor Vergata", Italy)

This contribution addresses the electromagnetic feasibility of a wireless temperature monitoring inside a portion of a high-power high-frequency Cyclotron Auto-Resonance Maser (CARM) for plasma heating in the new generation of DEMO TOKAMAK machines. The scenario is investigated as potential communication channel for a UHF RFID sensor network where a cavity probe is used to both excite the coaxial cavity and to collect the temperature data scattered back by sensor antennas. Some preliminary designs and prototypes of a simplified model of the cavity and of the reader/sensor devices permit to quantify the feasibility of the architecture and to evaluate the power bounds for stable communication and sensing.

Low Profile RFID Transponder on Conductive and High Permittivity Lossy Dielectric Platforms

Branimir Ivšić (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia); Anja Kuštra (University of Zagreb, FER, Croatia); Juraj Bartolić (University of Zagreb, Croatia)

The design of folded dipole similar to quarter-wavelength rectangular microstrip patch antenna is shown. A coplanar feeding structure is integrated in the flat radiator and accommodated to accept an RFID microchip to yield efficient operation in body-centric and highly conductive environments. Based on such antenna, an efficient transponder is designed, manufactured and experimentally verified. The transponder showed good isolation between radiating structure and the human body or a conductive platform in 870 MHz band. The reading range of the proposed transceiver is compared with the commercial one.

Coupled Dipole Antennas for on/off-body Communications at 2.45 GHz

Haoran Su and Robert Michael Edwards (Loughborough University, United Kingdom); Elijah Adegoke (Loughborough University & HSSMI, United Kingdom)

In this paper, three experiments with coupled dipoles were carried out in order to determine the optimal distance where an efficient communication link can be established. The simulations results showed that when the subcutaneous dipole is installed adjacently to the surface of the skin, the dipole mounted above the skin level should be in the range of 20 mm to 25 mm for efficient communication. Subsequently, the influence of the dielectric parameters of the human tissue on wave propagation has also been presented in this work.

Compact Planar Yagi-Uda Antenna with Improved Characteristics

Hemant Kumar and Girish Kumar (IIT Bombay, India)

In this paper, two different designs of 3-element planar Yagi-Uda antenna based on the shape of driven and reflector elements are studied. To feed the driven element of Yagi-Uda antenna, a tapered microstrip balun is designed, which converts unbalanced coaxial feed to balanced microstrip line feed. Measured results of both the antennas are compared and it is shown that a planar Yagi-Uda antenna using tapered shaped dipole elements is more compact and has better characteristics in terms of bandwidth, front to back ratio and gain than that using normal rectangular shaped dipoles. For Yagi-Uda antenna using tapered dipoles, measured bandwidth is 18.6% for return loss less than 10 dB. Maximum gain is 6.4 dBi with less than 1 dB variation over the bandwidth. Measurement shows a peak front to back ratio of 30 dB.

Inkjet-Printed Pixel Antennas with Hexagonal Cells

Bariscan Karaosmanoglu, Sadri Guler, Hande Ibili and Ozgur Ergul (Middle East Technical University, Turkey)

We present a new type of pixel antennas involving hexagonal unit cells that are suitable for fabrication in low- cost inkjet-printing setups. Antennas are optimized in a rigorous simulation environment based on the multilevel fast multipole algorithm integrated into genetic algorithms. Hexagonal cells are suitable for both the optimization environment and fabrication setup. Optimizations are performed particularly to design radio-frequency-identification tags, by removing pixels from a given template to achieve the best performance, e.g., minimum reflection coefficient values and maximum reading ranges. The overall design, optimization, and fabrication procedure has a fast demand response, requiring only one day from a request to the prototype stage.

Design of a Dielectric Waveguide Antenna at Microwave Frequencies

Linghui Kong (KU Leuven, Belgium); Xuezhi Zheng (Katholieke Universiteit Leuven, Belgium); Sen Yan (KU Leuven, Belgium); Guy A. E. Vandenbosch (Katholieke Universiteit Leuven, Belgium)

A dielectric waveguide antenna for X-band is designed. A printed dipole fed by a coplanar strip excites the Ex11 mode inside the dielectric waveguide. The waveguide mode in its turn excites a properly dimensioned patch, which generates the radiation pattern. Simulations are conducted from the stand-alone waveguide up to the complete structure to reveal the coupling and scattering effects between the substrate waveguide and the patch radiator. A pair of prototypes is manufactured and measurements are performed.

Adapted Raised Cosine Window Function for Array Factor Control with Dynamic Range Ratio Limitation

Filipe Santos and Joaquim Azevedo (University of Madeira, Portugal)

The use of window functions to improve the side lobe level of antenna arrays is hindered by high value of excitation currents dynamic range ratio. This paper proposes a fast and iterative window function generation strategy aimed at achieving improved side lobe level starting from a preset current dynamic range ratio. Based on this strategy a new window function is develop for standard set of conditions.

Circular Array Antenna for UAV-UAV Communications

Xiaoliang Sun (Technical University of Madrid, Spain); Rodrigo Blazquez-Garcia (Universidad Politécnica de Madrid, Spain); Alejandro García-Tejero (Technical University of Madrid, Spain); José-Manuel Fernández-González, Mateo Burgos-García and Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

Nowadays, the communications links limit the autonomy of unmanned aerial vehicles (UAV). In this paper, a multichannel long-range communication link for UAVs with high quality of service, moderate bandwidth and affordable cost is proposed. This link is deployed by using a second UAV as a communications relay and it provides bidirectional coverage for telemetry and telecommand and a high-capacity downlink for video. Our highly compact system can be installed on medium-sized UAVs for air-air links in order to offer greater flight autonomy. This system is based on an active circular array of linearly polarized circular patch antennas which are selectively activated depending on the desired direction of the beam.

Directive Array Based Pattern Reconfigurable Antenna

Kranti Kumar Katare and Animesh Biswas (IIT Kanpur, India); Karu Esselle (Macquarie University, Australia)

In this paper, a high-gain pattern reconfigurable antenna system is presented. It consists of one driven monopole antenna at the centre, which is surrounded by six parasitic elements. Each parasitic element made up of metallic strip, loaded with switch and backed by dielectric layer. Parasitic elements will behave like transparent and opaque surface to a vertically polarized incident wave for OFF and ON states of switch respectively. Therefore entire assembly becomes reconfigurable and beam steering is achieved. Proposed antenna offers a high and uniform gain of ~ 8 dBi with beam steering along the entire azimuth plane. The simulation has been carried out for ISM band (fr=2.45 GHz) using CST Microwave studio software.

Gain Enhancement of Pattern Diversity Antenna by Improving Phase Uniformity

Kranti Kumar Katare and Animesh Biswas (IIT Kanpur, India); Karu Esselle (Macquarie University, Australia)

A pattern diversity antenna, loaded with dielectric phase correcting structure is investigated. Antenna system is fed through monopole, which is surrounded by reconfigurable frequency selective reflector (RFSR). Each RFSR is connected to ground plane via switch. In ON state of switch corresponding RFSR behaves as reflecting surface, whereas it'll become transparent for the OFF state of switch. Thus beam steering can be achieved along the entire azimuth plane by configuring the switching states. Dielectric phase correcting structure (PCS) is incorporated in the direction of beam for transforming non-uniform phase distribution of vertically polarized electric field to nearly uniform phase distribution, which in turn enhances the gain of unloaded antenna by 1.5-2.0 dBi. The simulation has been carried out for ISM band (fr=2.45 GHz) using CST Microwave studio software.

Flexible and Cost Effective Reconfigurable UHF RFID Antenna System

Enrico Tolin (Politecnico di Torino, Italy & IMST GmbH, Germany); Achim Bahr (IMST GmbH, Germany); Matthias Geissler (IMST, Germany); Francesca Vipiana (Politecnico di Torino, Italy)

In this paper a reconfigurable matching network for achieving frequency agility of an electrically small UHF RFID patch antenna is proposed. In order to allow switching under high power transmission a state-of-the-art SP3T CMOS switch is employed for selecting peculiar components and thus achieving a proper matching in the EU and US frequency bands. Moreover, in the proposed design, only one switch is used instead of four needed in standard aperture tuning approaches. An optimized design of a RFID microstrip antenna has been simulated, showing good performance and high grade of flexibility of this technique that, for its low cost and high integration rate, can be an alternative to aperture tuning for frequency agility purpose.

2D Angle of Arrival Estimations and Bandwidth Recognition for Broadband Signals

Noori BniLam (University of Antwerp - iMinds, Belgium); Jan Steckel (University of Antwerp - Cosys-lab Research Group, Belgium); Maarten Weyn (University of Antwerp - iMinds, Belgium)

In many angle of arrival (AoA) estimation algorithms for broadband signals a-prior knowledge about the impinging signals' bandwidth is required for the algorithms to function. In this paper, we present a new technique for estimating the AoA and the bandwidth of the received broadband signals without requiring any knowledge of the bandwidth of the received signals. The proposed technique consists of a uniform circular array (UCA) followed by a transversal filter. It employs variable bandwidth spatial vectors along with the signal to thermal noise ratio (STNR) estimator to estimate the AoA and the bandwidth of the received signals simultaneously. The simulation results illustrate the capabilities of the proposed technique in estimating not only the elevation and the azimuth of the impinging signals with different bandwidths, but also the bandwidths of these received signals.

Experimental DoA Estimation Performance of the Co-array Concept

Jiachen Wang (KU Leuven, Belgium); Rubén Mena (ETSIT, Departamento de Comunicaciones, Universidad Politécnica de Valencia, Spain); Guy A. E. Vandenbosch (Katholieke Universiteit Leuven, Belgium)

In previous studies, it has been proven that by applying the co-array concept, we can detect the Direction of Arrival (DoA) of more sources with less antenna elements. This paper investigates two parameters that have a crucial influence on the co-arrays' DoA estimation performance in practical tests: near field conditions and a multi-path environment.

3D Compact Antenna Using Liquid Metal and Additive Technologies

Mathieu Cosker (University Nice-Sophia Antipolis, CNRS, LEAT, France); Leonardo Lizzi (Université Côte d'Azur, CNRS, LEAT, France); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Robert Staraj (University of Nice-Sophia Antipolis, France); Jean-Marc Ribero (Université de Nice Sophia Antipolis, France)

This paper presents a miniature antenna in Ultra High Frequency (UHF) band fabricated using liquid metal and additive technologies. Such an approach allows the accurate realization of compact and complex antenna

structures. The design as well as the realization of the antenna are discussed. In order to assess the effectiveness of the proposed solution, simulated and measured results are reported. The antenna small dimensions and good efficiency make it a good candidate for internet-of-things (IoT) applications.

Characterization of the Lossyness of Matching Networks for RF Energy-Harvesting Rectennas

Yen-Sheng Chen and Cheng-Wei Chiu (National Taipei University of Technology, Taiwan)

In general, a radio-frequency (RF) energy-harvesting rectenna uses the same structure as that for dedicated RF sources, although the level of input power is completely different. Few studies have investigated whether this situation needs a specific rectenna configuration, and the loss of rectenna elements for low-input-power scenarios has not yet been fully characterized. The purpose of this conference paper is to analyze the lossyness of impedance matching networks for RF energy-harvesting rectennas. The input power studied in this work ranges from -20 dBm to 0 dBm. We evaluate the additional loss of impedance matching networks, showing that the overall efficiency may decrease 95 percent in the worst case. Therefore, we suggest that the rectenna aiming at RF energy harvesting must remove the matching network, provided that the antenna impedance is directly conjugate matched to the input impedance of the rectifier.

Probabilistic VOR Error Due to Several Scatterers - Application to Wind Farms

Remi Douvenot, Ludovic Claudepierre, Alexandre Chabory and Christophe Morlaas (ENAC, France)

This paper introduces a method to calculate the VOR error due to multipaths from several known scatterers within known quantiles. In such a configuration, the amplitudes of the multipaths can be numerically or analytically calculated, whereas their phases are modelled as uniformly distributed. A probabilistic formulation of the VOR error that overestimates its variance is introduced to obtain the quantiles. The method is useful to obtain probabilities of occurrence of large VOR errors for multiple configurations and in a short computation time. Examples with wind farms are presented.

Viewpoint Correction for Polarimetric Turntable Inverse Synthetic Aperture Radar

Thomas Dallmann and Dirk Heberling (RWTH Aachen University, Germany)

Turntable ISAR imaging systems generate radar images by rotating the radar target and performing measurements at various angles. The rotation leads to different perspectives onto the scattering centers of the target. This causes problems if polarimetric methods should be applied to the radar image. In this paper this problem is investigated and a correction technique suitable for two-dimensional imaging is proposed. The correction mitigates the effects of a change in perspective. Additionally a criterion is presented which allows to optimize the corrected results in a way which is advantageous for a subsequent polarimetric processing. A comparison of radar images with and without application of the proposed methods shows the validity of the approach.

A Method of Range Measurement Based on High Resolution Range Profile

Xiaoliang Yang (National University of Defense Technology, P.R. China); Fen Ye (Huayin Ordnance test Center of China, P.R. China); Gongjian Wen, Baiyuan Ding and Yi Ge (National University of Defense Technology, P.R. China)

In conventional methods, the weighted mean range of the scattering centers on the high resolution range profile(HRRP) is assumed as the range between the target center and radar. However, this assumption is not reasonable because the scattering center with the maximum amplitude may not locate at the center of the target. In this paper, we proposed a novel range measurement method based on HRRPs. In the proposed method, HRRPs at different target poses are first predicted by the three-dimensional electromagnetic model (3-D em-model) of the target. Then, a slide correlation is conducted to measure the similarity between the HRRP of measurements and the HRRPs predicted by the 3-D em-model. Since the target center is already marked in the 3-D em-model, the position of the target center can be obtained through the correlation. Experimental results using simulated data validate the effectiveness of the proposed method.

A Novel Multi-Tag Identification Technique for Frequency Coded Chipless RFID Systems Based on Look-Up-Table Approach

Ahmed Elawamry (University of Duisburg-Essen, Germany); Maher Khaliel (Universität Duisburg-Essen, Germany); Abdelfattah Fawky (University of Duisburg Essen, Germany); Thomas Kaiser (Universität Duisburg-Essen, Germany)

The main objective of this contribution is to introduce a novel multi-tag anti-collision protocol based on Look-Up-Table (LUT) scheme. The proposed protocol includes an enhancement for the spectrum utilization and coding capacity. This is accomplished by transferring the tag-ID to be stored in a table in the main memory of the reader (look-up-table). Moreover, the unique signature of each tag represents the address of the tag's ID. The proposed protocol is modeled and simulated for identifying 10-chipless tags in order to set the regulations of the tag and reader design. Moreover, a novel real-world testbed for the multi-tag UWB chipless RFID system based on a software defined radio is introduced. In this testbed, all the signaling schemes related to the transmitted signal, detection techniques, empty room calibration for the clutter removal process and identification protocol are applied.

Frequency Coded Chipless RFID Tag Localization Using Multiple Antennas

Abdelfattah Fawky (University of Duisburg Essen, Germany); Maher Khaliel (Universität Duisburg-Essen, Germany); Ahmed Elawamry (University of Duisburg-Essen, Germany); Thomas Kaiser (Universität Duisburg-Essen, Germany)

In this paper a frequency coded chipless RFID localization algorithm is proposed. Unlike other techniques, one reader with multiple antennas is used to interrogate, identify and localize the tag. The Received Signal Strength (RSS) technique is used to detect the range of the tag, while Matrix Pencil Method (MPM) is used to calculate the Angle of Arrival (AoA). To validate both techniques a ray tracing tool was used to calculate the system link budget using tag RCS patterns exported from CST-MWS. The ray-tracing tool also calculated the interrogation zone considering all environmental factors. Moreover, a real-time testbed was created using fabricated chipless tags. The testbed was implemented using both measurement tools and Software Defined Radio (SDR). Both simulation and

measurements show a great potential for the chipless tag to be used in localization and tracking application.

Indoor Measurements of IoT Wireless Systems Interfered by Impulsive Noise From Fluorescent Lamps

Iratxe Landa, Aitor Blázquez, Manuel Velez and Amaia Arrinda (University of the Basque Country, Spain)

This paper presents the methodology and results of several trials carried out in order to test the effects of impulsive noise source in IoT wireless systems. The impulsive noise generated by fluorescent lamps at 433 MHz and 868 MHz has been measured and recorded. Using these measurements an impulsive noise generator has been developed. Then, with the generated noise two IoT systems have been interfered and the results have been analyzed. The studied systems are a remote control operating at 433.92 MHz and intelligent lighting based on Z-Wave protocol at 868.42 MHz. The methodology of the procedure is explained and the most relevant results are exposed.

Preliminary Results of Medium Wave Mobile Reception Measurements in a Dense Urban Region

Elizabeth Verdugo (PUC/RIO); Luiz A R da Silva Mello (PUC/RIO & Inmetro, Brazil); Marta Almeida (Inmetro, Brazil)

This paper presents preliminary results of medium wave mobile measurements campaigns carried out in a dense urban region in Brazil. The large-scale and small-scale fading were obtained, as well as probability distribution functions of these signals. The results presented here include daytime and nighttime statistics of the mobility measurements results.

Classification of GNSS SNR Data for Different Environments and Satellite Orbital Information

Rameez UR Rahman Lighari, Markus Berg, Erkki T. Salonen and Aarno Pärssinen (University of Oulu, Finland)

In this paper, a data classification method for analyzing the aspects of Signal-to-Noise Ratio (SNR) for Global Navigation Satellite System (GNSS) in real conditions is introduced. Different parts of measured environments and the orbital information of satellites are used as criteria for data classification. It consists of: 1) taking fish eye images of measured routes; 2) dividing measured environments into four potential sub environments (open area, forest area, single building blockage, and street canyon); 3) classifying satellites into nine different groups as function of elevation angles; and 4) creating a table containing the information of mean and standard deviation of SNR for different environments and satellite elevation angles. Results show good correlation of SNR's between same sub environments for different satellite elevation ranges which offer useful insight to regenerate a generalized set of SNR parameters in the laboratory environment for the development of 3D GNSS channel model.

Water Vapor Density Profile Statistics in the Atmospheric Boundary Layer

Pavel Valtr (Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic); Pavel Pechac (Czech Technical University in Prague, Czech Republic); Martin Grabner (Czech Metrology Institute, Czech Republic)

One year statistics of water vapor density is presented. Measured data presented were obtained using meteorological sensors mounted on a mast, thus having very good height and temporal resolution. Measurement results are in the form of surface water vapor density and water vapor density gradient. Results of measurement data analysis are compared with values recommended by ITU-R.

An Assessment of Different Optimization Strategies for Location Tracking with an Android Application on a Smartphone

David Plets (Ghent University - iMinds, Belgium); Alexander Sels (UGent, Belgium); Jens Trogh (Ghent University, Belgium); Kris Vanhecke (Ghent University - imec, Belgium); Luc Martens (Ghent University, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper presents a study of the efficacy of different optimization strategies for location tracking on an Android App that is run on a smartphone. The basic algorithm determines the most probable path of the user within a WiFi network by comparing raw RSSI measurements at each location with values in a fingerprint database. The investigated optimization strategies include: accounting for previous locations, increasing the number of WiFi scans per location, applying a Kalman filter, exploiting accelerometer data, shifting the frequency band from 2.4 to 5 GHz, and changing the position of the smartphone with respect to the body. It is shown that especially the accelerometer data allow enhancing the location estimation significantly. By combining different techniques, an average accuracy better than 2 m can be achieved.

TOP

Poster_04

Wireless Networks / Regular Session / Antennas

Room: Poster Sessions: Corridor Paris

Chairs: Juha Ala-Laurinaho (Aalto University, Finland), Philippe Ratajczak (Orange Labs, France)

Compact Dual-band WLAN(2.45/5.5 GHz) Antenna for USB Dongle Application with Reduced EMI Toward Laptop Circuit Board

Yunnan Jin and Jaehoon Choi (Hanyang University, Korea)

A compact dual-band antenna for WLAN (2.45/5.5 GHz) application is proposed. The proposed antenna consists of

two inverted L-shaped radiating elements, a slotted ground plane, a U-shaped shorted metal rim, and a loop feeding structure. The antenna satisfies the -6 dB reflection coefficient bandwidth requirement in WLAN (2.45/5.5 GHz) bands. To apply the proposed antenna to a practical laptop, an equivalent laptop circuit board is considered in this work. This antenna attains a multiband, size miniaturization, and EMI reduction toward a laptop main board. In addition, this antenna reduces the electric field radiated toward the main electric device after plugging into a dongle.

Omnidirectional Dual-Reflector Antennas for High Directivity over Wideband in Millimeter Waves

Rafael A. Penchel (São Paulo State University (UNESP), Brazil); Sandro R. Zang and Jose R Bergmann (PUC-Rio, Brazil); Fernando Moreira (Federal University of Minas Gerais, Brazil)

This work presents a study of the electromagnetic performance of classical and shaped omnidirectional dual-reflector antennas in millimeter waves. An algorithms based on the concatenation of conic sections has been used to synthesize sub- and main-reflectors in order to provide a uniform phase and amplitude aperture distributions. The frequency analysis is focused on antenna radiation patterns across a 20% bandwidth, in order to establish band limits for omnidirectional dual-reflector antennas. The rigorous electromagnetic analysis was accomplished by a hybrid technique based on Mode Matching and Method of Moments.

On Error Rate Performance of a MIMO WLAN System in the Indoor Hotspot Scenario

Xiaoming Chen (Qamcom Research & Technology AB, Sweden); Qi Wu and Shuang Guo (Beihang University, P.R. China)

In this paper, the error rate performance of a multiple-input multiple-output (MIMO) wireless local area network (WLAN) system is evaluated in the indoor hotspot scenario. A realistic three-port MIMO antenna is used at the access point (AP), whereas dipole antennas are assumed at the user terminal. The effects of the channel delay spread and oscillator phase noise on the MIMO WLAN system are studied with respect to the IEEE 802.11n protocol.

A CPW-Fed Compact Dual-band Short-Ended ZOR Antenna with Backed Ground Plane for Wi-MAX Applications

Reshma Singh (Indian Institute of Technology (ISM) & India, India); Rajkishor Kumar (Indian Institute of Technology (ISM), India); Raghvendra Kumar Chaudhary (Indian Institute of Technology (ISM) Dhanbad, India)

a CPW-fed compact dual-band short-ended ZOR antenna with backed ground plane is investigated. Designed antenna is short-ended therefore ZOR frequency depends on series LC lumped parameters. Overall electrical size of designed antenna is 0.145λ0 × 0.2267λ0 × 0.01423λ0 at ZOR . The proposed antenna offers dual-band behavior with -10dB impedance bandwidth of 5.14% and 30.37%.

A Compact Four-element MIMO Antenna Based on HMSIW Slot Antenna

Wei Ming (Xi'an Research Institute of Navigation Technology, P.R. China); Liu Hu (Xidian University, P.R. China); Wan Tao (Xi’an Research Institute of Navigation Technology, P.R. China); Ying Liu (Xidian University, P.R. China)

A novel four-element MIMO antenna operating at millimeter wave band is proposed. The half-mode substrate waveguide(HMSIW) cavity slot antenna is used as the element to realize a compact structure, high radiation efficiency and interelement isolation. The simulated relative impedance bandwidth is 29.6% from 23.5-31.0GHz for S11<-10dB. And the isolation is lower than -22dB across the operating band without any additional coupling reduction structure.

60 GHz Low Cross Polarized E-Plane AFTSA-SC Array Architecture

Zouhair Briqech (Institut National de la Recherche Scientifique - INRS, Canada); Shraman Gupta and Abdel R. Sebak (Concordia University, Canada); Tayeb A. Denidni (INRS-EMT, Canada)

A four element low cross polarization sine corrugated antipodal Fermi tapered slot antenna (AFTSA-SC) based on E-plane array architecture is designed to operate at 60 GHz and to cover the ISM band. The single element antenna is capable of achieving wide bandwidth (55-65 GHz) with a stable gain (~15 dB) and 88 % total radiation efficiency. A 1 × 4 AFTSA-SC array with E-plane array architecture is analyzed comparing conventional and mirrored array structures. These two array structures have better, and improved antenna gain (~ 20 dB), low sidelobe level (SLL), and reduced cross-polarization while maintaining the antenna's stable radiation characteristics. The proposed mirrored array architecture improved the cross polarization level by 16 dB as a result of which the E-plane AFTSA-SC array architecture is capable of achieving a high gain at E-plane with a narrow beamwidth, lower SLL and improved X-Pol than with the H-plane.

Low Cross Polarized AFTSA-SC H-Plane Array Architecture for MMW Applications

Zouhair Briqech (Institut National de la Recherche Scientifique - INRS, Canada); Shraman Gupta and Abdel R. Sebak (Concordia University, Canada); Tayeb A. Denidni (INRS-EMT, Canada)

This paper presents a high gain, and low cross polarized four element sine shaped antipodal Fermi tapered slot antenna (AFTSA-SC) based on H-plane array architecture that operates at 57-64 GHz for applications in millimeter wave systems. The proposed antenna consists of circular slots and sine-shaped corrugation to enhance the radiation characteristics of the antenna. This antenna is analyzed in H-plane array architecture comparing conventional and mirrored array structures. The performance of the 1 × 4 AFTSA-SC array is investigated not only for lower cross-polarization, but also regarding achieving high gain, better radiation characteristics, and low side lobe level. The proposed mirrored H-Plane array structure exhibits a gain of 20 in addition to good cross-polarization, which is less than −40 dB in both the E- and H-planes at 60 GHz.

Design, Fabrication and Characterization of a New Wideband Antenna Based on a

Polyaniline/Carbon Coated Cobalt Composite

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)

The new generation of polymer materials has the facility to conduct electricity, radiate and concurrently be flexible. Accordingly, the possibility of implementation of a flexible antenna opens the door to many interesting applications including body-worn ones. This paper presents the design of a CPW-fed monopole antenna, based on a Carbon coated Cobalt (CCo) charged Polyaniline (PANI). A wideband antenna design approach is proposed to develop a single antenna that can be employed by diverse wireless technologies. In particular, in this paper the frequency bands of interest are [2.4 - 2.48] GHz (WiFi) and [5.15-5.825] GHz (wireless networks). Conception, realization and characterization steps of the composite based wideband antenna are presented. The composite (PANI/CCo) fabricated, whose morphology was studied via scanning electron microscopy, has a conductivity of 7500 S/m. The antenna is printed on a 130µm thick Kapton® substrate. A good agreement between measurements and simulation data is observed.

Electrically Small Structural Antenna Design for Small UAV Based on Characteristics Modes

Sek-Meng Sow (National University of Singapore & Temasek Laboratories, Singapore); Lu Guo (National University of Singapore, Singapore); Shi-Gang Zhou (Temasek Laboratories, National University of Singapore, Singapore); Tan-Huat Chio (National University of Singapore, Singapore)

A systematic approach in developing a 4-port structural antenna on a Small Unmanned Aerial Vehicle is presented. The largest dimension of the SUAV is 0.67 wavelength of the operating frequency. Using Characteristic Mode (CM) Analysis, two CMs with good radiation efficiency are identified. The radiation patterns of these CMs can be synthesized by combining the individual element gain patterns with specific amplitude and phase settings. In addition, the radiation pattern may be gradually steered from one CM to another by progressively changing the phase settings. A 1:5 scaled model is fabricated and the respective CMs are excited; the gain patterns are measured in an anechoic chamber. The resulting gain patterns can be combined either via a suitable RF combiner or digitally beamformed. In both cases, the results agree well. This method may be used to provide steering, albeit limited, of the gain pattern of an electrically small structural antenna.

Investigation of Multi-Beam Multi-Port MIMO Antennas for WLAN/WiMAX Applications

Yan Pan, Yuehui Cui and RongLin Li (South China University of Technology, P.R. China)

Dual-polarized triple-band multi-beam multiple input multiple output (MIMO) antennas are developed for WLAN/WiMAX access points. A four-beam MIMO antenna and a thirty-two-port four-beam MIMO antenna are investigated for high-capacity and wide-coverage wireless applications in high-density environment.

Analysis and Design of a Broadband Dual-Polarized Planar Antenna for 2G/3G/4G Base Stations

Yuehui Cui and RongLin Li (South China University of Technology, P.R. China)

A broadband dual-polarized dual-dipole (DPDD) planar antenna is analyzed and designed for 2G/3G/4G base stations. The DPDD antenna consists of two perpendicularly crossed dual-dipole elements. Each dual-dipole element is comprised of two identical side-by-side dipoles which are connected through a coplanar strip line that also acts as an impedance transformer. Two dual-dipole elements are printed respectively on two sides of a thin substrate and are excited directly by two coaxial cables, making the antenna configuration planar, compact, and simple.

Compact Microstrip Antenna with Triple-Band Triple-Mode and Triple-Polarization Characteristics

Zuping Qian (PLA University of Sci. & Tech., P.R. China); Wenquan Cao, Yang Cai and Yingsong Zhang (PLA University of Science and Technology, P.R. China)

This paper presented one novel microstrip antenna with triple-band triple-mode and triple-polarization (TBTMTP) characteristics. In the lower frequency band, the antenna operates in the linearly polarized (LP) dipole mode with omnidirectional radiation pattern along the YOZ plane which is like one horizontally located dipole antenna. In the middle frequency band, the antenna operates in the LP dipole mode with omnidirectional radiation pattern along the XOY plane which is like one vertically located dipole antenna. While in the upper frequency band, the antenna works in the circularly polarized (CP) patch mode with directional radiation patterns along the Z-axis direction. Due to mutual-coupling periodical circular patches and inductance metal pins connecting the upper and lower patches, the three modes can be excited in three different bands. By etching inverted L shaped slot in the down circular mental patch, CP is realized for the patch mode without affecting the other two modes.

Compact Penta Band Printed Slot Antenna for GSM, Bluetooth, WiMAX, 4G LTE, and WLAN Applications

Mohammad Mehdi Samadi Taheri and Abdolali Abdipour (Amirkabir University of Technology, Iran); Gert Pedersen (Aalborg University, Denmark)

In this paper a compact penta band printed slot Antenna suitable for GSM/Bluetooth/LTE/WiMAX/4G/WLAN application is presented. The antenna is flower shape printed slot antenna which operates in wide band frequency range. By inserting elliptic shape protrudent stubs in the ground plane, some rejection bands in the pass band are attained. The antenna covers GSM and 4G (LTE) bands at center frequencies of 1.8 GHz, Bluetooth at 2.4 GHz, WiMAX at 2.5, 3.5, and 5.8 GHz, WLAN at 2.4, 5.2, and 5.8GHz. the antenna has a good omnidirectional radiation pattern and good matching (S11< -10 dB) all over the passed frequency bands.

A Wideband Endfire CP Antenna Using Magnetic Dipole

Min Li, William S. W. Cheung, Bo Wang and Ti Yuk (The University of Hong Kong, Hong Kong)

This paper presents a wideband circularly polarized (CP) antenna with high gain and end-fire radiation. The antenna consists of two metal strips on the same side of two substrates separated at a distance of 0.09 wavelength. The two metal strips are shorted together at three edges. Two pairs of tapered stubs are protruded from the metal strips to generate two resonances and two orthogonal electric fields with 90o-phase difference, resulting in a wideband CP antenna. Simulation results show that the antenna has a wide impedance bandwidth (IMBW) of 2.31-4.00 GHz (53.6%) for S11<-10 dB and axial-ratio bandwidth (ARBW) of 2.30-3.81 GHz (49.4%) for AR<3 dB. Stable endfire radiation is observed over the operating bandwidth with a peak gain of 7.83 dBi. The antenna is a good candidate for uses in radio frequency identification (RFID) readers to cover the ISM band.

Two-Port Compact Wideband Planar MIMO Antenna

Mirmehdi Seyyedesfahlan (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland); Ibrahim Tekin (Sabanci University, Turkey)

A wideband dual feed antenna is designed and manufactured for multi-input, multi-output (MIMO) application. The antenna is optimized to match the ports to 50 ohm, and adjust the isolation between the ports for more than 15 dB in 2-6 GHz frequency band. The disk is fed using the microstrip transmission lines with 90° angular spacing to reduce the cross polarization and hence coupling between the ports. Due to the disk radiator, the antenna can be utilized as a two ports omnidirectional antenna. The antenna is measured for S-parameters and gain that comply well with the simulations. Antenna measured gain varies between 2.3 dBi and 6.3 dBi for 2-6 GHz. The antenna can be employed as a two port compact antenna, for multiband communication in 2-6 GHz and for WLAN applications.

Split Ring Resonator with Rotated Inner Ring for Microstrip Circular UWB Antenna

Mousa Hussein, Elham Serria, Ali Hakam and Indu Rajmohan (UAE University, United Arab Emirates (UAE))

3x3 Split Ring resonators with inner ring rotation are etched at the back side of Circular microstrip antenna with elliptical rings. Rotation for multiple angles leads to an enhancement in impedance bandwidth. The selected UWB antenna has fabrication dimensions of 45 mm×31 mm×1.27 mm. The rotation of the inner rings occur clockwise and counter clockwise for -47°, 33° and 10°. The preferable enhanced frequency bandwidth is between 2.2 GHz and 9 GHz with return loss up to -28dB at 3.8 GHz. S11, VSWR, maximum gain and group delay are obtained for the new design of the antenna via HFSS. This method of rotating inner or outer rings of SRRs will have massive researches in the near future.

Low-Cost Wideband Antenna on Paper Substrate

Hong Phuong Phan (IMEP-LAHC, Grenoble INP & Ho Chi Minh city University of Technology, France); Tan Phu Vuong (Grenoble INP-MINATEC, France); Philippe Benech (Université de Grenoble-Alpes, Laboratoire IMEP–LAHC, France); Pascal Xavier (UJF Grenoble, France); Pascal Borel and Anastasia Delattre (CTP Grenoble, France)

In this paper, a wide-band monopole antenna structure printed on 104-um E4D paper, a thin, flexible and low cost substrate, has been proposed. For the design process, E4D paper was characterized to obtain its electromagnetic properties by the cavity perturbation method with a cylindrical cavity. Then the antenna was designed and optimized to a wide range of frequency, from 2 GHz to 10 GHz focusing on two WLAN bands. Our proposed antenna is thin, flexible, rather compact, has good performance with the return loss of over 20 dB at 2.45 GHz, over 30 dB at 5.5 GHz. It exhibits very large bandwidth (2.15 GHz to over 10 GHz). The radiation patterns are nearly omni-directional at 2.45 GHz and more directive at 5.5 GHz. The design was realized by screen printing technology at CTP. The measurement results are in good agreement with the simulation which confirms the validity of the design.

A Wide-band Circularly Polarized Slot Antenna by Using Novel Feeding Structure

Mohammad Saeid Ghaffarian and Gholamreza Moradi (Amirkabir University of Technology, Iran); Pedram Mousavi (University of Alberta, Canada)

A novel single-feed wide band planar circularly polarized (CP) slot antenna is presented. This slot antenna consists of an L-shaped feeding stub with metamaterial inspired complementary split ring resonator (MICSRR) and a wide 45º rotated square aperture. Broadband impedance and CP radiation bandwidth (BW) is achieved by using a novel artificial exciting stub with defecting CSRRs on it. By controlling the excitation phase of L-shaped stub, a desirable circular polarization can be generated and both impedance and CP BWs are considerably increased by up to 89%. The operating frequency ranges in S/C band from 2.4-6.22 GHz. The measured bandwidths of 3-dB axial ratio (AR) and VSWR<2 are around 91% (2.4-6.4 GHz) and 89% (2.4-6.22 GHz), respectively.

Compact Wideband Circularly Polarized Slotted Ground Plane Antenna for Mobile Terminals

Oluyemi Peter Falade (Queen Mary University of London, United Kingdom); Xiaodong Chen (Queen Mary, University of London, United Kingdom); Clive Parini (QMUL, United Kingdom)

A low cost, simple and compact wideband circularly polarized slotted ground plane antenna design is proposed for mobile terminal. The dual annular perturbation slots antenna with asymmetric stub is built on the grounded substrate. The antenna is design to operate in a wideband that covers 1.85-3.02 GHz frequency band at 10 dB. The circularly polarized radiation patterns have been achieved through the perturbation of the ring slots and the optimization of the asymmetric stubs and the slotted ground plane. The antenna is fed by a single microstrip line place beneath the substrate. A prototype of the proposed antenna has been fabricated and experimentally validated in an anechoic chamber.

An X-type CRLH Leaky Wave Antenna with Low Cross-Polarization

Yu-Wei Wang and Yao-Wen Hsu (Graduate Institute of Communication Engineering, National Taiwan University, Taiwan); Yi-Cheng Lin (National Taiwan University, Taiwan)

we designed a leaky wave antenna based on X-type composite right/left handed (CRLH) transmission line. Due to the wide-band nature of X-type CRLH transmission line, the antenna can provide a wide impedance bandwidth. The antenna can provide 5dB scanning pattern from 5.6GHz to 7.6GHz. The presented antenna shows a significantly low level of cross-polarized patterns using the balanced symmetric.

Characteristic Modes Optimisation Approach to Design a Wideband Electrically Small Antenna

Hussein Jaafar (Universté de Rennes1 & IETR, France); Sylvain Collardey (University of Rennes 1, France); Dominique Lemur (IETR, Universite' de Rennes 1, France); Abdullah Haskou (IETR UMR CNRS 6164, Université de Rennes1, France); Ala Sharaiha (Université de Rennes 1 & IETR, France)

A design methodology based on the combination of the Theory of Characteristic Modes (TCM) with an Optimization Algorithm, to design a wideband Electrically Small Antenna (ESA) is presented. Unlike other design techniques, loads or matching networks are not needed at the input of the antenna. A design example of an Inverted-L Antenna (ILA) is presented to validate the effectiveness of this technique.

SAR Impact Evaluation on Jeans Wearable Antennas

Ignacio Gil (Universitat Politècnica de Catalunya, Spain); Raul Fernandez-Garcia (Universitat Politecnica de Catalunya, Spain)

This paper addresses the effects of two main microstrip wearable antennas on the specific absorption rate (SAR) on the human trunk as well as their impact performance in terms of gain, efficiency and required area. Rectangular patch and PIFA jeans wearable antennas intended for wireless body area network applications at 2.45 GHz are under analysis. The SAR values averaged over 1 g and 10 g tissue of a realistic voxel model are computed according to the IEEE/IEC 62704-1 standard. The results are compared with the limits of exposure determined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the IEEE C95.1.

Dual-Band WLAN Button Antenna for Both on and off-Body Applications

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

A novel button antenna for WLAN applications is proposed. The antenna is composed of a button on top of a dielectric disc. The button is located on top of a textile substrate and a conductive textile ground. This antenna shows two different types of radiation patterns, a monopole type pattern in the 2.4 GHz band and a broadside type pattern in the 5 GHz band, thus both on and off-body function can be achieved. Measurements agree very well with simulations.

Design of a Pattern Reconfigurable Antenna with Single Patch Base on Butler Matrix Feeding Network

Wang Yi and Tao Wan (Xi'an Reserch Institute of Navigation Technology, P.R. China); Bochao Yang (Xi'an Research Institute of Navigation Technology, P.R. China)

A novel pattern reconfigurable antenna with single microstrip patch which excited by a butler matrix network for wireless communications is presented. Four steerable beams including boresight, conical and two slant patterns are obtained by changing the current distribution on the patch. The dimensions of the proposed antenna are 100×100×3 mm3 and it is fabricated and tested. Base on the -10 dB return loss, the operating bands can be employed between 2.3-2.5 GHz, which 8% bandwidth for center frequency.

Highly Broadband Circular Polarized Patch Antenna with 3 Phase Feed Structure

Robin Theunis and Maarten Baert (KU Leuven, Belgium); Paul Leroux (Katholieke Hogeschool Kempen, Belgium); Wim Dehaene (Katholieke Universiteit Leuven, Belgium)

In this paper a highly broadband circularly polarized patch antenna design is shown. The design features several novelties which includes the use of a 3-phase feed circular patch for optimal axial ratio and the 3-phase microstrip feed structure to excite the patch antenna. Combining those techniques provides superior bandwidth in both return loss and axial ratio compared to classical rectangular patch designs as shown by simulation and measurements.

Reducing the Width of Planar Yagi-Uda Antennas Using Square-Shaped Split Ring Resonators (SRRs)

Pau Aguilà (Universitat Autònoma de Barcelona, Spain); Gerard Zamora (Universitat Autonoma de Barcelona, Spain); Simone Zuffanelli (Universitat Autònoma de Barcelona, Spain); Ferran Paredes (Universitat Autonoma de Barcelona, Spain); Ferran Martín (Universidad autónoma de Barcelona, Spain); Jordi Bonache (Universidad Autónoma de Barcelona, Spain)

A novel planar Yagi-Uda antenna is proposed in this work. The canonical dipole resonators constituting the driven, reflector and director elements are replaced here with square-shaped split-ring resonators (SRRs). This solution allows for a reduction of the width of the antenna roughly by a factor of two, while maintaining good radiation performance. As a proof of concept, a 5-elements prototype working within the WLAN frequency band is designed and fabricated. The measurements exhibit reasonably good agreement with simulations, and highlight the validity of the proposed approach for obtaining compact Yagi-Uda arrays in planar geometry.

A 2x2 Integrated Filter Antenna Array

Anuj Kumar Sahoo (PDPM IIITDM Jabalpur, India); Ravi Dutt Gupta (PDPM-Indian Institute of Information Technology, Design and Manufacturing, India); Manoj Singh Parihar (IIITDM, India)

This paper deals with a 2x2 Integrated Filter Antenna (IFA) array designed at 5.2 GHz. By incorporating the filtering action in the conventional antenna array the need for an additional filter following the antenna array, for suppressing the out-of-band signals, has been avoided. To achieve this, the last resonator of the filter has been replaced by a slot antenna operating at the same band as that of the filter in each arm of the array. The overall dimension of the subsystem has been optimized to 1.56λ0 x 1.56λ0. It has got a fractional bandwidth of 3.0% at 5.2 GHz. The sub-system provides a maximum gain of 12.43 dBi and HPBW of 33 degrees in broadside direction. The proposed structure was designed, simulated and fabricated. The measured reflection co-efficient plot shows a shift of 0.09 GHz of the overall band which may be due to the fabrication tolerances.

Suppression of Mutual Coupling in Wideband Tree Shaped Fractal DRA Array for MIMO

Applications

Kedar Trivedi (Institute of Technology, Nirma University, India); Dhaval Pujara (Nirma University, India)

A closely spaced two-element wideband tree shaped fractal dielectric resonator antenna (DRA) design with low mutual coupling over a wide band of 4.05-10 GHz is proposed. By properly arranging array elements, and using C-shaped periodic defected ground structure (PDGS), mutual coupling reduction has been achieved. Mutual coupling less than -15dB over the entire band of interest is achieved. Conformal strip feeding of trapezoidal shape is used to achieve wide bandwidth of about 84.7%. Different design parameters, radiation patterns with and without PDGS and its associated results are discussed in this paper.

Green 4g Radio Network Planning

George Tsoulos, Georgia E. Athanasiadou, Ioannis Valavanis and Dimitra Zarbouti (University of Peloponnese, Greece)

Energy-efficient planning is a challenge for heterogeneous 4g wireless networks, since 'greener' strategies typically act against the growing traffic requirements. However, network- wide optimization of base-station antenna patterns can be exploited to that end, leading the total transmit power of the network to a global minimum. This article formulates the coverage and capacity optimization problem in the context of 4g systems and uses a multi-objective genetic algorithm in order to optimize each sector transmitted power, as well as antenna pattern with respect to its pointing direction and 3dB beamwidth. The proposed optimization algorithm is applied to provide the most power efficient network setup that, can be also optimized to leave the least possible coverage holes in the network area in exchange of further power reduction. The trade-off between transmitted power and coverage can be observed leaving further choices to the network designer.

Frequency Reconfigurable Patch Antenna with Defected Ground Structure Using Varactor Diodes

Zakaria Mahlaoui (Cadi Ayyad University, Morocco); Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain); Hamza Benchakroun (Cadi Ayyad University, Spain); Adnane Latif (Cadi Ayyad University, Morocco)

This paper presents an approach that combines two methods for reducing the size of a patch antenna and obtaining a wide tunability frequency range. The addition of a slot in the ground plan helps to shift down the basic frequency of the patch from 7.273 GHz to 4.267 GHz without modifying the basic geometry of the antenna. By modifying the varactor values, a series of successive bands are obtained, ranging from 4.65 GHz to 6.18 GHz. Accurate simulations are performed by using S-Parameter varactor data files. The patch antenna is suitable for U-NII band applications.

Unidirectional Frequency Reconfigurable Bow-Tie Antenna Array with AMC Reflector

Qi Li (China Academy of Space Technology (Xi'an), P.R. China); Tong Li (Air Force Engineering University of CPLA, P.R. China); Zhipeng Li and Jinyong Fang (China Academy of Space Technology (Xi'an), P.R. China)

A unidirectional frequency reconfigurable bow-tie antenna array (FRBAA) is presented. The array employs four doubled-sided bow-tie antennas as the radiating elements. By controlling the states of the PIN diodes mounted on the radiators, three switchable operating bands can be achieved. In order to produce unidirectional radiation patterns with low profile and good impedance matching in all the bands, a tri-band artificial magnetic conductor (AMC) is designed and incorporated with the array. The distance between the array layer to the AMC reflector is only 0.032λ0 at the lowest operating frequency (2.4 GHz). The integration of the AMC not only yields good front-to-back ratios, but also improves the forward gains in all the operating bands.

Systematic Design of 3-port Bug-like MIMO Antenna Based on Theory of Characteristic Mode

Dong-Woo Kim and Sangwook Nam (Seoul National University, Korea)

In this paper, 3-port bug-like MIMO antenna design based on theory of characteristic mode is proposed. The proposed antenna has compact size of 30×70× 10 ??? and it operates at 2.4-GHz ISM band. We present novel design approach for 3-port MIMO antenna. First, as it is bilateral symmetric structure, it is possible to decompose characteristic currents with even/odd currents with respect to axis of symmetry. Second, we define characteristic current correlation for finding optimal position of excitation for 3-port MIMO antenna. Finally, we design systematic design of antenna and decoupling and feeding networks by using antenna as a ground plane. Results show that the proposed 3-port MIMO antenna is appropriate to MIMO communication systems in bilateral symmetric structure.

Broadband Collocated Antennas with Three Orthogonal Polarizations

Halim Boutayeb (Antenna Department, Huawei Technologies Canada Co., Ltd., Kanata, Canada); Paul Watson (Huawei Technologies, Canada)

In this work, new designs of three collocated antennas, with orthogonal polarizations, are presented. These types of antennas can find applications in Multiple Inputs Multiple Outputs (MIMO) systems or in base stations antenna arrays. A cross-dipoles and a folded monopole are designed and optimized. Two configurations are analyzed at 2.45GHz and 5.5GHz with broadband and high isolation performance characteristics. The monopole is tested with two or four arms, and the dipole height is either a quarter-wavelength or half-wavelength for broadside or conical radiations. Numerical and experimental results are presented to validate the proposed concept.

A Novel Band Pass Filter Using Radial Stub for GSM Applications with Stopband for GPS

Hossein Omidi (Iran University of Science and Technology, Iran); Morteza Nadi (Iran University of Science & Technology, Iran); Homayoon Oraizi (Iran University of Science and Technology, Iran)

This paper presents a novel approach for designing bandpass filter to global system for mobile communication and stop band for global positioning system. Its configuration consists of is composed of coupled radial stubs and two short circuited stubs on the input and output lines. It has a sharp roll-off and provides a narrowband bandpass

filter with 3dB fractional bandwidth of 8.1% in global system for mobile communication band and an insertion loss of 0.5 dB. The transmission zero is located on the global positioning system band. The measured results exhibit good agreement with the simulations.

Design of A Dual-Notched Ultra-Wideband (UWB) Planar Antenna Using L-Shaped Bandstop Resonator

Sam Weng Yik (UTEM, Malaysia); Zahriladha Zakaria (Universiti Teknikal Malaysia Melaka, Malaysia)

In this paper, a novel UWB printed circuit board antenna with dual band-notched characteristics is presented. The antenna consists of a circular patch with two pairs of the L-resonator. To realize the notch characteristics in WLAN at 5.2 GHz (5.15-5.35 GHz) and 5.8 GHz (5.725-5.875 GHz) bands, the half wavelength of L-resonator is introduced in the radiating patch. The T-shape notch is etched in the ground plane to enhance the bandwidth which covers the resonant frequency range from 3.048-10.561 GHz. The effects of L-resonator on the band-notched characteristics are also investigated. The proposed antenna with band-notches shows good impedance matching for the simulated in the physical layout. Furthermore, the proposed antenna has a compact size of 29 x 40 mm2. This proposed design can provides an alternative solution for the UWB wireless system in the designing of a band-notched antenna with a very good notch band.

Preliminary Investigation of Power Delay Profile Computation from Full Wave Frequency Domain Indoor Propagation Model

Ian Kavanagh and Conor Brennan (Dublin City University, Ireland)

New developments in energy efficient wireless communications systems and indoor location and tracking algorithms have created a greater demand for accurate propagation models. In this paper a frequency domain full wave propagation model is used to produce accurate power delay profile information. The propagation model is based on the volume electric field integral equation (VEFIE). The VEFIE is solved in two dimensions at a number of frequencies and the fourier transform is applied to convert the frequency domain data to the time domain. The generated PDP is compared against the well known theory of geometrical optics and a very good agreement is achieved. The effects of finite bandwidth and resolution on the PDPs are also investigated.

Efficient Feedback Quantization for WLAN

Moussa Diallo, Diop Idy and Dioum Ibra (UCAD, Senegal)

We present an efficient feedback quantization technic for beamforming matrix compression. The proposed technic named time domain quantization TD-Q relies on the feed back of time domain parameters necessary for the reproduction of the beamforming matrix at the transmitter. This TD-Q presents the same performance than the conventional Givens rotation quantization GR-Q and requires less amount of feedback. The quantization error, BER performance and amount of feedback of the proposed TD-Q are studied and compared with the GR-Q in IEEE 802.11ac context.

Antenna Design for Underwater Wireless Telemetry Systems

Thierry Deschamps de Paillette (Université de La Rochelle, France); Alain Gaugue (La Rochelle University, France); Emmanuel Parlier and Sylvain Dardenne (Flex-Sense, France)

Underwater environmental sensor networks require wireless communications that can be performed using electromagnetic waves. Water induces both conduction and dielectric losses. Thus, antenna design is a key factor regarding the global performance of such underwater transmission systems. In this article, the study of the seawater properties leads to comparing the conduction and dielectric propagation modes of an electromagnetic wave. A simulation model of an original antenna design is proposed to optimize link budget in underwater communication systems.

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Chairs: Ana Arboleya (Universidad de Oviedo, Spain), Pawel Kabacik (Wroclaw University of Technology, Poland)

The SKA Low-Frequency Telescope: Performance Parameters and Constraints on the Array Configuration

Maria Grazia Labate, Peter Dewdney, Robert Braun, Mark Waterson and Jeff Wagg (SKA Organisation, United Kingdom)

The SKA1-LOW radio telescope will be a low-frequency (50-350 MHz) aperture array composed by ~130,000 antenna elements spread over tens of kilometers and located in Western Australia. Its scientific objectives will prioritize studies of the Epoch of Reionization and pulsar physics. This paper will focus on the key performance parameters and constraints driving the architectural design of the World's largest antenna array.

Micro-Wave Imager Radiometer Antennas Configurations

Alfredo Catalani (Space Engineering, Italy); Laurent Costes (Airbus Defence and Space/ADS, France); Alessandro Esposito (Space Engineering, Italy)

MWI (Micro Wave Imager) is a multi-channel microwave radiometer which will be embarked on the next MetOp-SG mission aimed to provide cloud and precipitation observations as well as water vapour and temperature gross profiles. MetOp-SG includes two series of three satellites, embarking a total of 10 different instruments. The present paper provides a general description of the MWI antenna design and its performance. As it is well known,

the antenna system has an important role for both the radiometric accuracy and the spatial resolution of the instrument, since it has to guarantee at the same time very good beam efficiency and high spatial resolution. . The antenna is able to operate over the frequency range between 18 GHz and 200 GHz, split in eight main frequency bands, each one receiving up to 5 channels as defined by the user requirements.

Wideband Circularly-Polarized 3-bit Transmitarray Antenna in Ka-Band

Fatimata Diaby (Université Grenoble-Alpes & CEA, France); Antonio Clemente (CEA-LETI Minatec, France); Luca Di Palma (Space Engineering S.p.A., Italy); Laurent Dussopt (CEA, LETI, Minatec, France); Kien Trung Pham (Ho Chi Minh City International University, Vietnam); Erwan Fourn (INSA of Rennes & IETR, France); Ronan Sauleau (University of Rennes 1, France)

This paper describes the design of a Ka-band 3-bit circularly-polarized transmitarray antenna. The array is based on a unit-cell composed of two U-shaped slot loaded patch antennas, which are connected by a metallized via hole and printed on two identical dielectric substrates. A 400-element transmitarray is simulated and demonstrates a maximum gain of 27.5 dBi, an aperture efficiency of 47.8%. The 1-dB gain-bandwidth (LHCP) corresponds to 14.8% at 29 GHz. The 1-dB axial ratio bandwidth covers the frequency band between 27 - 32 GHz. A good agreement is obtained between the full-wave simulation results performed with Ansys HFSS and the ones obtained using our hybrid in-house simulation tool. The impact of phase quantization on the performance of a 40×40-element array is also presented. The corresponding radiation patterns (co- and cross-polarization components) are compared to the masks defined by the European International Standardization Institutions (ETSI) in the case of point-to-point applications.

Structured Surface Design to Generate Any Beam Pattern at THz Frequencies

Fabien Defrance (Observatoire de Paris, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France); Julien Sarrazin (University of Pierre & Marie Curie UPMC, France); Martina Wiedner (Observatoire de Paris - LERMA, France); Hugh Gibson (Gibson Microwave Design EURL, France); Gregory Gay (Observatoire de Paris - LERMA, France); Roland Lefèvre (ELORPrintTec, France); Yan Delorme (Observatoire de Paris - LERMA, France)

An iterative alternate projection-based algorithm is developed to design structured surfaces able to generate any far-field beam pattern at GHz and THz frequencies. To validate the algorithm, two structured profiles (a reflective one and a transmissive one) are designed to generate four beams of similar intensity at 610 GHz. The two prototypes are fabricated and tested to experimentally evaluate their performance. Experimental measurements confirm a good agreement with computer simulations using Feko and, therefore, validate the method.

Wideband Circularly Polarized Triangular-Ring Slot Antenna for GAIA-I Microsatellite

Asif Awaludin (Chiba University & Indonesia National Institute of Aeronautics and Space, Japan); Josaphat Tetuko Sri Sumantyo (Chiba University, Japan); Steven Gao (University of Kent, United Kingdom); Cahya Santosa (Chiba University, Indonesia); Zafri Baharuddin (Chiba University & Universiti Tenaga Nasional, Japan)

A novel compact size equilateral triangular ring-slot antenna is proposed for microsatellite. The presented antenna utilizes truncation, perturbation, and slits to generate wideband circular polarization (CP) operation from its inherited linear polarization. The fabricated antenna has wide CP performance of 1106 MHz or 52.27% of fractional bandwidth at 2116 MHz center frequency. The measured results show that the antenna is bidirectional with its RHCP operation is radiated in main lobe. There is good agreement between simulated and measured radiation patterns.

Genetic Algorithm Application on a Tightly Coupled Array Antenna

Iman Farhat (University of Malta, Malta); Kristian Zarb Adami (University of Oxford, United Kingdom); John Abela and Charles Sammut (University of Malta, Malta)

A synthesis of a genetic algorithm (GA) and an electromagnetic software (EM) application to guide the design and optimisation of tightly coupled phased array antennas is presented. This technique is biased to satisfy certain desired specifications subject to the mid-frequency SKA radio astronomy. Tightly coupled arrays are a practical realisation of the current sheet model~(CSA) for an array with a wideband characteristic. However, the analysis aims for an optimal impedance matching response. Technically, the EM programme computes the electrical property of the antenna design in implemented MATLAB optimisation loop. The design is verified using both simulations and measurements of a manufactured prototype. A wide bandwidth was achieved exceeding the design specifications set out.

Waveguide Septum Polarizer Shaped with Legendre Polynomials

Jean-Christophe Angevain (ESA, The Netherlands); Nelson Fonseca (European Space Agency, The Netherlands)

This paper presents the design and performance of a contoured septum waveguide polarizer where the longitudinal profile of the septum blade is shaped with Legendre polynomials. A performance comparison with a conventional septum polarizer based on a blade with a stepped profile is performed at Ka-band (27.5 - 30.0 GHz) to show the merit of the proposed profile shaping. Preliminary results indicate an increase in frequency bandwidth of about 20% combined with a length reduction of 5.5%. This compact 3-port waveguide device can be used to generate either dual-circular or dual-linear tilted polarization.

Wideband Pyramidal Sinuous Antenna for Reflector Antenna Applications

Nicol Steenkamp and Dirk de Villiers (Stellenbosch University, South Africa); Ngoy Mutonkole (University of Stellenbosch, South Africa)

This paper presents a wideband pyramidal sinuous antenna, over a conducting ground plane, for use as a reflector antenna feed. Specific attention is given to comparisons with a similar structure where the sinuous shape is instead projected onto a cone. The pyramidal structure is significantly simpler to manufacture, and measured results confirms this where close agreement with simulations is observed.

Electromagnetic Analysis of High Frequency Radomes for Ground Stations in Polar Regions

Andrea Martellosio, Marco Pasian and Luca Perregrini (University of Pavia, Italy); Luca Piffer and Roberto Riccardi (FDS ITALY, Italy); Filippo Concaro (European Space Agency, Germany); Pier Mario Besso (Esa – Esoc, Germany)

At lower frequencies the radome design for ground stations can be considered consolidated, and the microwave transparency can be often obtained with minimal compromises on the structure stiffness. Conversely, at K-band frequencies and above the two domains, electromagnetics and mechanics, require a joint design to achieve best performance, especially when installations at environmentally extreme locations are required. Notably, next generation satellites for Earth Observation, aimed to provide large amount of data exploiting high frequencies, require ground stations at Polar latitudes, where the combination of high-speed winds and low temperature is particularly severe. This paper provides a comparison between two possible solutions for the radome suitable for this kind of installation. In particular, both the transparency of radome walls and the Induced Field Ration of radome interconnections are evaluated. As a test case, a radome to be installed in Svalbard for a European Space Agency ground station is discussed.

Circularly-Polarized Leaky-Wave Antenna at Ka-Band

Darwin Blanco and Ronan Sauleau (University of Rennes 1, France)

A novel low profile circularly-polarized (CP) leaky-wave antenna (CP-LWA) is introduced while the simplicity of the linearly-polarized (LP) primary feed is maintained. The proposed antenna uses a broadband polarizer above a classical LWA. The achieved axial ratio (AR) is kept below 2 dB within a bandwidth of 31$\%$ ranging from 26.7 GHz to 35.5 GHz. All results are verified via full-wave simulations over an angular variation of $\pm$41 deg.

Easy-to-Deploy LC-Loaded Dipole and Monopole Antennas for Cubesat

Korbinian Schraml (RWTH Aachen University, Germany); Adam Narbudowicz (Dublin Institute of Technology, Ireland); 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)

This paper proposes a new approach to reduce weight and complexity of VHF/UHF cubesat antennas by utilizing a dual band antenna, rather than standard two-antenna system routinely implemented in cubesats. Three systems are compared: A standard system with separate transmit/receive dipoles, a dual-band dipole for both transmit and receive and a dual-band monopole, which uses the body of 1U cubesat (10 × 10 × 10cm) as a "groundplane". Additionally it is demonstrated that with appropriate feed the dipole might be used in monopole configuration in case of deployment system malfunction.

Comparison of a Four Stage Sequentially Rotated Wideband Circularly Polarized High Gain Microstrip Patch Array Antennas at Ku-Band

Roshin Rose George and Alejandro T Castro (San Diego State University, USA); Satish K. Sharma (San Diego State University & San Diego State University, USA)

Two sequentially rotated, four stage, wideband circularly polarized high gain microstrip patch array antennas at Ku-band are investigated and compared by incorporating both unequal and equal power division based feeding networks. Four stages of sequential rotation is used to create 16×16 patch array which provides wider common bandwidth between the impedance matching (S11 $<$ -10dB), 3dB axial ratio and 3dB gain of 12.3% for the equal power divider based feed array and 13.2% for the unequal power divider based feed array in addition to high polarization purity. The high peak gain of 28.5dBic is obtained for the unequal power division feed based array antennas compared to 26.8dBic gain in the case of equal power division based feed array antennas. The additional comparison between two feed networks based arrays reveals that the unequal power divider based array antennas provide better array characteristics than the equal power divider based feed array antennas.

SAR Array Synthesis for Next Generation Earth Observation Systems

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

A novel synthesis methodology for fast and robust design of synthetic aperture radar (SAR) arrays for Earth observation is proposed. An innovative integer coding of the discrete problem unknowns (i.e., the magnitude and phase of the array elements in transmission/reception) is introduced to sensibly reduce the dimension of the search space with respect to the standard binary coding and enable the design of large arrangements. Moreover, suitable customizations of the genetic algorithm (GA) operators (i.e., selection, cross-over and mutation) are exploited for an effective exploration of the solutions, by minimizing highly non-linear/unconventional cost functions linked to specific SAR system quality indicators. Some illustrative numerical benchmarks are illustrated in order to verify the effectiveness of the proposed design technique for the synthesis of next generation radars.

Design of Overlapped Sub-arrays for Planar SparseDirect Radiating Arrays

Theodoros Kaifas and Dimitrios G. Babas (Aristotle University of Thessaloniki, Greece); John Sahalos (Aristotle University of Thessaloniki, GR, Thessaloniki & University of Nicosia, CY, Nicosia, Greece)

In the current work we focus on sparse array design employing overlapping radiating elements. In this case, the underlying sparse grid shapes the broadside directivity farfield pattern while the overlapping flat-top producing subarrays eliminate the scanning loses. In detail, when overlapping arrays are involved the design process is as follows: Perform broadside design, (not scanning beam), using elements' size that keeps Grating Lobes just out of the Field of View (FoV). Since we use Flat-top elements their directivity is reduced and thus their number and/or their size should be increased to balance the two directivity trends. If the element number increase in the previous step is lower than the respective increase due to scanning losses when employing non-overlapping arrays, (and non-Flat-topped element), then we have an accepted solution; In most of the cases, this means that using overlapping we achieve a remarkable reduction in the number of control points.

Wideband High-Efficiency Unit-Cell for 1-bit and 2-bit Transmit-Arrays Operating in X-Band

Hamza Kaouach (LATIS - National Engineering School of Sousse, Tunisia)

A new attractive elementary cell is proposed for 1-bit and 2-bit transmit-arrays in X-Band, where the wideband and low loss characteristics are crucial. The proposed unit cell consists of two identical square patch antennas include C-loop slot and interconnected in their centers by a metalized via hole. The unit cell exhibits a simple three-layer metallic structure and allows standard printed-circuit board fabrication technology. The elementary cell is designed and verified using finite element method simulation. A waveguide measurement system (WGMS) has been utilized for S-parameters characterization. An excellent agreement has been obtained between the simulations and the measurements in terms of impedance matching (S11<-10dB for the range 9.39 GHz -10.26 GHz, 8.8% around 9.85 GHz) and insertion loss (0.36 dB at 9.85 GHz). The proposed unit cell is an excellent candidate for a 1-bit active cell by integrating two PIN diodes in the order to control its transmission phase.

A Study of Wideband Reflectarray Antenna Using Ring-Style Resonator Elements

Takeshi Shiode (Mitsubishi Electric Corporation, Japan); Kento Takeshima and Shigeru Makino (Kanazawa Institute of Technology, Japan); Michio Takikawa, Yoshio Inasawa and Hiroaki Miyashita (Mitsubishi Electric Corporation, Japan)

A wideband design method for reflectarray antennas with conventional ring-type resonator elements is proposed. It is shown that the one of the causes of the narrow bandwidth is the inadequate attenuation of higher order Floquet modes in the substrate. As the dielectric substrate thickness increase, the more the higher order modes are attenuated. Therefore, the substrate thickness is the important parameter for wideband reflectarray antennas. The condition of the substrate thickness for wideband characteristic is shown, and the validity is verified by analyzing reflectarray antennas.

Reflectarray Element Analysis Based on Generalized Sheet Transition Conditions

Xiao Liu, Fan Yang, Maokun Li and Shenheng Xu (Tsinghua University, P.R. China)

The surface electric and magnetic susceptibilities and the surface impedance of an array composed of periodic scatterers are derived based on generalized sheet transition conditions. Using these characteristic parameters, the reflection coefficient of a reflectarray element can be readily computed for arbitrary incident angles, polarizations, and frequencies. The detailed procedure is described and its validity is demonstrated through comparisons with full wave simulations.

A Circuit-Driven Design Methodology for a Wideband Linear-To-Circular Polarizer

Mehdi Hosseini and Sean V Hum (University of Toronto, Canada)

The paper presents a design methodology to achieve a wideband circular polarizer with a relatively low thickness of one-fifth of a free-space wavelength. A three-layer planar structure is devised to exhibit transparency to both TE and TM polarized fields while imparting a quadrature phase difference between them, as required for the generation of circularly-polarized fields. The structure is designed using a circuit-driven approach whereby an independent equivalent circuit describes the behavior of each constituent polarization. Meanwhile, the small unit cell size endows the structure with a low sensitivity to the angle of incidence of the impinging waves. This polarizer with a unit cell volume of $0.13\lambda_0 \times 0.13\lambda_0 \times 0.21\lambda_0$ renders axial ratios of less than 3dB and 1dB over ~25% and 9% fractional bandwidths, respectively. Numerical simulations verify the accuracy of the circuit-driven approach and its applicability as a design tool in the synthesis of this class of polarizer.

A Portable Measurement Setup for Characterizing Circular Polarization Selective Structures

Andreas Ericsson, Daniel Sjöberg and Johan Lundgren (Lund University, Sweden)

We present a measurement procedure to characterize the transmission and reflection properties of a circular polarization selective structure using linearly polarized antennas in a portable measurement setup. By applying careful alignment when assembling the setup, together with certain post processing techniques, the circular polarization scattering of a device under test can be accurately determined, both in transmission and reflection.

Design of Planar Metallic Microwave Lenses for Multiple Spot-Beam Systems

Hon Ching Moy-Li and Daniel Sanchez-Escuderos (Universidad Politécnica de Valencia, Spain); Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

This paper presents a microwave planar lens formed by a multilevel frequency selective surface (FSS) aimed at increasing the gain of a radially-corrugated horn antenna. The FSS is formed by three layers of square loops with open stubs. The phase compensation is achieved by shifting the resonant frequency of the unit cell. To do so, only the length of the stubs is suitably adjusted, leaving the rest of geometrical parameters unaltered from one cell to another. Results show an increment of 3.5 dB at 20.1 GHz in the directivity of the planar lens with respect to the feeding horn antenna.

Complementary Metaresonators Based X-Band Hollow Waveguide Filter and Crack Detection Sensor

Safiullah Khan (Technical University of Munich, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

A new metamaterial based subwavelength resonators configuration for X-band hollow waveguides is proposed and its application as a filter and crack detection sensor is discussed. The structure is composed of a complementary rectangular split ring resonator embedding a T-type resonator. The filter has a 0.9 GHz bandwidth at 9.11 GHz resonance frequency. The comparison between a perfect surface and a defected surface is presented and observations are made using signal comparisons. Around the resonance frequency the signal comparison shows the difference in the reflection behavior for both the surfaces when the width and the depth of the crack are varied. The technique can be extended to study the material characteristics of different media.

Integration of Resistive Heaters for Phase-Change Reconfigurable Antennas

Dimitris Anagnostou (Heriot-Watt University (UK), United Kingdom); David Torres (Michigan

State University, USA); George Goussetis and Symon K. Podilchak (Heriot-Watt University, United Kingdom); Tarron Teeslink and Nathan Kovarik (South Dakota School of Mines and Technology, USA); Nelson Sepulveda (Michigan State University, USA)

Vanadium dioxide has recently been proven successful as a mechanism of reconfiguration of an antenna. We present and discuss the integration of resistive heaters underneath the surface of the vanadium dioxide thin film, on the antenna wafer. These resistive heaters are important for the implementation of a biasing mechanism that is fast (in the range of microseconds) and that does not couple electromagnetic energy to the antenna structure. Results of antennas with and without the integrated heaters, along with additional applications of this technology will be presented and discussed.

Land-mobile X-band Satellite Measurements in Norway, Experiment Description and First Results

Vegard Arneson (FFI, Norway); Lars Erling Bråten (Norwegian Defence Research Establishment (FFI), Norway); Jostein Sander, Terje Mikal Olsen Mjelde and Oystein Olsen (FFI, Norway)

Findings from a vehicular satellite communication experiment at X-band along a 5460 km route in Norway was described in this paper. The elevation angle was between 10° in the North and 20° in the South. System availability, coverage and excess attenuation on a 7.25 - 7.75 GHz down-link from a geostationary satellite was found by measuring a satellite beacon. The purpose of the experiment was to investigate possibilities and challenges by utilizing vehicular satellite communications. It was found that the average availability of the time was 61.4 %. The average coverage of the distance was 56.1 %. Based on map data and measured GPS positions, the calculated fraction of distance with line of sight visibility to the satellite was 84 % and the vegetation shadowing was about 28 % of the total distance. Significantly better coverage requires alternatives such as diversity of satellites providing higher elevation angles.

Combined Beacon and Noise Satellite Propagation Measurements Using Software Defined Radio

Apostolos Z. Papafragkakis and Athanasios D. Panagopoulos (National Technical University of Athens, Greece); Spiros Ventouras (STFC Rutherford Appleton Laboratory, United Kingdom)

Considering the imminent migration of services to the Ka- and Q- bands, a payload dedicated to propagation measurements in these bands has become available from the Alphasat satellite under the coordination of the European Space Agency. This has strongly motivated the formation of many measurement campaigns across Europe in an effort to enhance the scientific databases with new, more reliable propagation data. In the framework of our campaign at the National Technical University of Athens (NTUA) in Greece two identical beacon receivers targeting the Alphasat's Ka-band beacon were designed and deployed; these receivers make use of the relatively new Software Defined Radio (SDR) paradigm. Apart from the beacon measurements themselves, additional noise measurements are performed to supplement the campaign. The present paper constitutes an attempt to outline the characteristics and associated advantages of this methodology over the conventional techniques.

Analysis of One-Year Data of Slant Path Rain Attenuation at 19 and 39 GHz in Prague

Martin Grabner (Czech Metrology Institute, Czech Republic); Ondrej Fiser (Institute of Atmospheric Physics & Fac. of Electrical Engineering and Informatics/Uni of Pardubice, Czech Republic); Viktor Pek (Institute of Atmospheric Physics CAS, Czech Republic); Pavel Pechac (Czech Technical University in Prague, Czech Republic); Pavel Valtr (Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic)

Attenuation time series measured on the satellite-to-ground path in Prague in frequency bands 19 and 39 GHz and simultaneously measured rain intensity are analyzed statistically using one-year dataset. Frequency scaling is described by linear models. Empirical power law models are fitted to the measured data directly and to the obtained annual cumulative distributions. Monthly statistics obtained shows the worst months in terms of rain attenuation. Fade slope and fade duration cumulative distributions are determined and discussed.

High-Order Evaluation and Modelling of Cross-Polarization Discrimination on Earth-Satellite Propagation Paths at Ka and V-Bands

Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal); Carlo Riva (Politecnico di Milano, Italy); Armando Rocha (University of Aveiro & Institute of Telecommunications, Portugal)

The SatComs performance employing frequency-reuse schemes to improve the spectral efficiency is degraded due to the depolarization-induced interference originated by hydrometeors present along the propagation path. Two models are able to account for all contributions: one enables the prediction of the first-order statistics (CDF) of cross-polarization discrimination (XPD), and another enables the prediction of the relationship between XPD and co-polar attenuation (CPA). The second was developed for the V-band and so, it requires independent validation and extension to other frequency-bands. The predictions provided by the first are usually converted on the corresponding XPD-CPA relationship using the long-term first-order statistics of rain attenuation, (wrongly) considering that the equiprobability base applies. Using 8 years of measurements both models are tested, a new regarding the XPD-CPA relationship is proposed for the Ka-band and another base to be employed on the conversion of the CDF of XPD on the XPD-CPA relationship is investigated.

Alphasat Experiment at Aveiro: Data Processing Approach and Experimental Results

Joel Flávio (Universidade de Aveiro, Portugal); Armando Rocha and Susana Mota (University of Aveiro & Institute of Telecommunications, Portugal); Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal)

The execution of propagation campaigns monitoring satellite beacons and assessing the Earth-satellite propagation channel is a demanding task, but absolutely necessary to deploy successfully future communication satellites operating at Q-band and above, where highly demanding satellite services can be offered given the wide bandwidth available at those frequency-bands. These campaigns require very high equipment availability, accurate measurements and careful data preprocessing to get time series of high quality for modelling purposes. A large

campaign is now being executed all over the Europe using the Alphasat satellite. Here we describe the experimental arrangement in Aveiro-Portugal, we report on some equipment tests that have been performed, and present an innovative approach to the preprocessing software. Finally, a few results (event based and statistical outputs) already obtained are also discussed.

Joint Results of the Aveiro and Vigo Alphasat Propagation Campaigns

Joel Flávio (Universidade de Aveiro, Portugal); Fernando Pérez-Fontán (University of Vigo, Spain); Flávio M. da Silva Jorge (Instituto de Telecomunicações & Universidade de Aveiro, Portugal); Susana Mota and Armando Rocha (University of Aveiro & Institute of Telecommunications, Portugal)

The usage of Fade Mitigation Techniques (FMT) is mandatory for satellite communications over 10 GHz once the atmospheric propagation effects get severe with the increase of the frequency-band. Site Diversity (SD) and Orbital Diversity (SD) are two effective techniques to mitigate rain attenuation. Considering an operation at Q-Band (40GHz), in this paper a SD scheme comprising the Aveiro and Vigo earth stations, located 177km apart, is exposed and an OD configuration, with an aperture angle of 18º at Aveiro, is preliminary investigated.

Annual Statistics of the Alphasat Ka and Q-band Propagation Channel in Budapest, Hungary

László Csurgai-Horváth and Bernard Adjei-Frimpong (Budapest University of Technology and Economics, Hungary)

The Alphasat telecommunication satellite was launched in July, 2013 and beside of the main payload it carries four scientific experiments. One of them is the Aldo Paraboni Scientific Experiment, a propagation experiment in the Ka and Q radio bands. The experiment is coordinated by the European Space Agency under the framework of ARTES 8 Telecom program. Hungary, similarly to other European experimenters established a receiver station in Budapest for each beacon transmitter channels of the satellite. This project was supported and financed by the European Space Agency. Our purpose was to record long time received power level time series of the Ka and Q-band satellite channel among relevant meteorological data as well. The station is operating with its full functionality since mid-2015 and the data collected so far permits the calculation of yearly attenuation statistics, demonstrating the monthly variations and allowing the comparison with relevant ITU-R statistics as well.

Experimental Analysis of Passive Intermodulation at TNC Coaxial Connectors

Rui Wang (National Key Laboratory of Science and Technology on Space Microwave, P.R. China); Wanzhao Cui (504th Research Institute, P.R. China); Chen Xiang (Xi'an Institute of Space Radio Technology, P.R. China); Chunjiang Bai (NKLSTSM, P.R. China); Na Zhang (China Academy of Space Technology (Xi'an), P.R. China); Yun Li (China Academy of Space Technology Xi an, P.R. China)

In this paper, the generation of passive intermodulation at standard TNC coaxial connectors is investigated. A series of tests has been performed in order to analysis the intermodulation level under different temperature circumstances. The relationship between the intermodulation response of the connectors and the change of temperature and straining on the junctions has been studied. It has been found that the passive intermodulation of TNC coaxial connectors was very sensitive to the changes of temperature and straining. High intermodulation should be caused when warming up from the low temperature.

Wednesday, March 22, 13:30 - 16:20

SWS_03: Nanotechnology Applications of Antennas and Wireless Sensing

TOP

WG Meetings & WorkShops: Room 315

Chairs: Krishna Naishadham (Georgia Institute of Technology, USA), Patrizia Savi (Politecnico di Torino, Italy)

Wednesday, March 22, 15:00 - 16:20

Inv_03 Invited Session 3

TOP

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Michael Jensen (Brigham Young University, USA), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

15:00 ***Channel Modeling for Dependable Vehicular Connectivity***

Christoph F Mecklenbräuker (Vienna University of Technology, Austria)

Vehicles and other road users will be linked to each other and the road infrastructure to make traffic more efficient, cleaner, and safer. For example, Vehicle-To-Vehicle (V2V) and Vehicle-To-Infrastructure (V2I) communication enables cooperation and intelligent route management in transport networks. To achieve these ambitious goals, wireless links must become dependable: The information relevant for intelligent transport systems (ITS) shall be shared reliably within a tolerated latency. Challenges for cooperative ITS are posed by nonstationary time-frequency-selective fading processes in vehicular channels. Fortunately, the nonstationary vehicular fading may be

characterized by assuming local stationarity for a finite region in the time-frequency plane. Thus, we characterize the channel by a local scattering function (LSF). High delay spreads are observed for rich scattering and high Doppler spreads characterize drive-by scenarios. These channel characteristics translate into packet error sequences exhibiting dependencies. Finally, we discuss packet error models of low complexity for large-scale cooperative ITS emulation.

15:40 ***Overview of OTA Testing of 5G Enabled Devices***

Philippe Garreau (Microwave Vision Group, France)

The promise of 5G and internet of things (IoT) is a future in which an inconceivable number of everyday devices are connected with incredible speeds. 4G was the first mobile system actually designed with global standardization. This was one of the key factors in the success of 4G and the speed of its deployment. Today, the main objective of the communication community is to realise common standards for 5G and build a global system. The deployment of test systems at various prestigious events will then follow. The 2018 Winter Olympics in Korea and the 2020 Summer Olympics in Japan are examples of such pilot systems. Finally, users will have 5G devices and will enjoy the full performance of this new technology. We know that test and measurements of 5G enabled devices and base-stations will differ widely from what we are doing today. 5G implies higher and widely available spectrum at frequencies up to 100GHz, which can accommodate the implementation of Massive-MIMO involving multiple small antennas and in-device processing. This will move the emphasis from the antenna towards system testing. Important parameters, determined from conducted testing for 4G, will likely be performed in Over-The-Air (OTA) setups in tomorrow's 5G. This puts a strong requirement on the measurement industry to provide effective testing solutions to developers, industries and regulators. As testing technology, the very effective multi-probe systems have evolved with the development of 1 to 4G technology in the last 25 years. It is today a reference for OTA testing of such devices. While concepts such as testing in near and far field (NF, FF) is less critical in current 1-4G standardisation, NF testing and NF performance of devices is likely to be a critical issue for 5G. In this paper/presentation we will give an introduction to existing measurement technology and a vision on the evolution of testing technology for 5G enabled devices.

TOP

Inv_04 Invited Session 4

Room: Oral Sessions: Auditorium Havane

Chairs: Joel Lemorton (ONERA, France), Fernando Pérez-Fontán (University of Vigo, Spain)

15:00 ***Antenna Technologies for Spaceborne SAR***

Pasquale Capece (Thales Alenia Space Italia, Italy)

The Presentation will provide an overview of the most significant Space Antennas for spaceborne SAR systems both based on planar aperture and on reflector systems. Active phased array architecture will be presented with focusing on RF aspects, digital distribution and power subsystem. Thermo-mechanical aspects will be also considered and discussed. An overview of the technologies used for radiating elements, TR modules and beam forming will be reported. Technology for Reflector antennas will be also presented including benefits and drawbacks vs planar systems.

15:40 ***The Characterization of the Atmospheric Radio Channel for Satellite Services, an Overview of ESA Activities***

Antonio Martellucci (European Space Agency, The Netherlands)

The effects of the propagation of radio waves in the atmosphere can be relevant for a number of Satellite services, including Satellite Communication (SatCom) systems, Global Navigation Satellite Systems (GNSS), Earth Exploration and Space Exploration systems. In particular the lower part of the atmosphere (i.e. the troposphere and to some extent also the stratosphere) induces several propagation effects, including attenuation, depolarisation, signal scintillation, noise emission, excess path length. These effects are relevant in all phases of a Space project, including preliminary and final design, in-orbit tests and operations. The effect of atmospheric propagation on Satellite services becomes more relevant as technological developments opens new frequency bands (see evolution of SatCom frequency bands from C up to W band), improves the performances of system components making more critical for the link budget the random contribution of atmospheric propagation or the system requirements impose a trade-off between system performances and system margins (e.g. between maximisation of data throughput and minimisation of system unavailability). In this framework the criteria for system design and control have to evolve from a classical static approach towards flexible and adaptive methodologies. This implies also the need to improve channel assessment techniques and to minimise the error of experimental measurements.This talk will present an overview of developments and channel modelling used by the European Space Agency in the framework of a number of ESA projects, including the Alphasat Aldo Paraboni (TDP5) experiment for SatCom services at Q/V band, contribution to Radio Regulations (ITU-R SG3), the development of models of tropospheric error for Galileo GNSS and its evolution, the use of Ka band for Earth Exploration missions (like METOP-SG) and support to radioscience experiments of Space Exploration missions (like Bepi-Colombo and JUICE, to Mercury and Jupiter).

IWS_04: Efficient simulation of antenna placement on different platforms (Aeronautical, Automotive, Naval,...)

TOP

WG Meetings & Workshops: Room 313/314

Chair: Eddy Jehamy (Altair FEKO, France)

Wednesday, March 22, 16:50 - 18:30

Sp_A03 Reflectarrays and Transmitarrays

Space / Regular Session / Antennas
Room: Oral Sessions: Auditorium Bordeaux
Chairs: Dirk de Villiers (Stellenbosch University, South Africa), Paolo Rocca (University of Trento, Italy)

16:50 ***Experimental Characterization of Dual Linearly Polarized Transmitarray Antennas At X-Band***

Trung Kien Pham (University of Rennes 1 & IETR, France); Ngoc Tinh Nguyen (University of Nice Sophia Antipolis, France); Laurent Le Coq (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 the detailed experimental characterization of X-band 400-element transmitarray antennas in dual linear polarization. The latter can radiate two different and independent beams in two distinct directions with orthogonal polarizations. Two prototypes are designed and fabricated at 10 GHz; one with two beams radiating at boresight, and one designed for two beams pointing in a different direction in each polarization. A 3-dB gain bandwidth of 20% is reached for both polarizations and maximum gain is over 25 dBi for broadside beam.

17:10 ***Tolerance Analysis of the Reflectarray Antenna Through Minkowski-based Interval Analysis***

Nasim Ebrahimi and Nicola Anselmi (ELEDIA Research Center, Italy); Paolo Rocca and Andrea Massa (University of Trento, Italy)

Having a robust architecture against tolerances is one of the most important aspects in high frequency antenna design. In this paper, the effect of fabrication errors on the power pattern of reflectarray antenna is investigated. The uncertainty on the actual size of the patch width is modeled with the interval values. The rules of Interval Arithmetic are then exploited to compute the bounds of the deviation in the resonance frequency, the reflection phase of each element and the radiated power pattern. Due to the redundancy of the Interval Analysis in complex domain, Minkowski sum is implemented to perform the summation. We show that the Minkowski-based Interval Analysis can produce a narrower and inclusive bound. To guarantee the validity of the model, a Monte Carlo test has been carried out to cover the Interval- Minkowski bounds.

17:30 ***Loss Analysis of a Reflectarray Cell Using ANNs with Accurate Magnitude Prediction***

Vincent Richard (Institut d'Electronique et de Télécommunications de Rennes, France); Renaud Loison and Raphael Gillard (IETR & INSA, France); Hervé Legay (Thalès Alenia Space, France); Maxime Romier (CNES, France)

This paper proposes a design methodology to improve the Artificial Neural Networks modeling of reflectarray cells with regards to the prediction of reflection coefficients magnitude. It is applied to model both types of RA cells (capacitive and inductive) with 5 inputs parameters. The results demonstrate that the final ANNs models are reliable and accurate with an average error on the reflection coefficient magnitude of the scattering matrix (|R11|) of -66dB and -69dB respectively for the capacitive and inductive cells. This accurate prediction of magnitude allows rejecting a priori any cell with loss exceeding a prescribed threshold. Comparison of two canonical reflectarray layouts shows the benefit that could be expected in a synthesis process.

17:50 ***Design of a 24 GHz Reconfigurable Transmitarray Element with Continuous Phase Range***

Martin Frank (University of Erlangen-Nuremberg & Institute f. Electronics Engineering, Germany); Robert Weigel (University of Erlangen-Nuremberg & Eesy-id, Germany); Alexander Koelpin (University of Erlangen-Nuremberg & Institute f. Electronics Engineering, Germany)

This paper presents a reconfigurable transmitarray antenna unit-cell for a frequency of 24 GHz. A continuous phase range is obtained by loading patches with varactor diodes on the outer layers of a printed circuit board (PCB) while the signal couples through slots in the inner layers. The design, numerical and experimental characterization of the unit-cell in a rectangular WR-42 waveguide are reported. A phase tuning range of 120° was achieved with a custom layer stack which could be extended to 145° using solely RF-substrates.

18:10 ***A Single Layer Stub-Patch Phoenix Cell for Large Band Reflectarrays***

Hassan Salti (Australian College of Kuwait, Kuwait); Raphael Gillard (IETR & INSA, France)

A novel Phoenix cell for large band reflectarray antennas is presented here. The cell starts with a simple square patch whose phase shift is controlled by its sides' length. The size of the patch is then fixed and open-stubs with variable length are connected to it. To complete the phase range at the central frequency, the stub-loaded patch then shrinks gradually until it disappears completely allowing the cell to rebirth. The cell is characterized by a phase range of 360° at the central frequency, linear phase responses with respect to frequency and a reduced phase dispersion of less than 34°/GHz within a 40% bandwidth. The suggested cell retains the same bandwidth when accounting for incidence angles of up to 30° and a reduced bandwidth of 32% accounting for higher incidence angles of up to 45°.

CS21 Innovative Antenna Architectures for Very High Throughput Satellite (VHTS) Systems

Space / Convened Session / Antennas
Room: Oral Sessions: Auditorium Havane
Chairs: Nelson Fonseca (European Space Agency, The Netherlands), Baptiste Palacin (CNES, France)

16:50 ***VHTS Systems: Requirements and Evolution***
Hector T. Fenech (Eutelsat S.A., France); Sonya Amos (Eutelsat, France); Antonin Hirsch (Eutelsat SA, France); Viphakone Soumpholphakdy (Eutelsat S.A., France)
EUTELSAT's first HTS system, KA-SAT is still the largest in Europe and very often a benchmark. Since then EUTELSAT has launched EUTELSAT 36C to deliver services over Russia and EUTELSAT 65A over LATAM. BB4A is currently under production to provide services over Africa. The requirements for HTS systems evolve and are mainly driven by economics trying to drive the cost of per unit capacity lower to remain attractive and gain new applications. The paper looks at the salient evolution of the requirements as HTS system evolve into VHTS.

17:10 ***Multibeam Antennas for Very High Throughput Satellites in Europe: Technologies and Trends***
Baptiste Palacin (CNES, France); Nelson Fonseca (European Space Agency, The Netherlands); Maxime Romier and Romain Contreres (CNES, France); Jean-Christophe Angevain (ESA, The Netherlands); Giovanni Toso and Cyril Mangenot (European Space Agency, The Netherlands)
This paper proposes an overview of recent CNES and ESA developments related to broadband satellite applications. Ka-band multi-beam antennas for user links and Q/V-band antennas for feeder links are crucial components to cope with stringent VHTS mission requirements. A brief presentation of technical trends since early 2000 is exposed with a specific focus on multi-beam antenna technology. Also, the main needs for upcoming VHTS systems and the key developments needed to increase significantly the overall system capacity of current satellites while maintaining total system cost competitive are presented.

17:30 ***Ka-Band User Antennas for VHTS GEO Applications***
Yves Demers (MDA Corporation, Canada); Eric Amyotte (MDA, Canada); Karim Glatre (MDA Corporation, Canada); Marc-André Godin (MDA, Canada); Jonathan Hill (MDA Corporation, Canada); Aiping Liang and Mathieu Riel (MDA, Canada)
Very High Throughput Satellite (VHTS) user antennas with their large number of beams and very large beam scans present several new design challenges. One of these challenges is to control scan aberrations as they lead to high scan losses, low C/I and ultimately, lower capacity. This paper presents a comparison between the results of various array-fed reflector antenna designs that are considered for VHTS missions.

17:50 ***Antenna Developments for Geostationary VHTS Satellites at Airbus Defence and Space***
Simon J Stirland (Airbus Defence and Space Ltd); Michael Schneider (Airbus, Germany); Steve McLaren (Airbus Defence and Space Ltd)
In recent years there has been an accelerating trend towards increasing numbers of Ku- and Ka-band beams in geostationary telecommunications satellites. In the near future it is expected that we will see requirements for several hundred if not thousands of such beams for the next generation of VHTS satellites. This will require a step change in antenna architectural design but equally importantly component level RF design as well as thermal and mechanical design. This paper provides an overview of developments in these areas in Airbus Defence and Space.

18:10 ***Application of Bifocal Concept to Dual Reflectarray Configurations for Multi-Beam Satellite Antennas in Ka-Band***
Eduardo Martinez-de-Rioja and Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Antonio Pino and Borja Gonzalez-Valdes (University of Vigo, Spain); Carolina Tienda (Airbus Defence and Space, United Kingdom); Sean V Hum (University of Toronto, Canada); Giovanni Toso (European Space Agency, The Netherlands)
This contribution describes the design of a multi-beam dual reflectarray antenna for operation in transmission in Ka-band (20 GHz). The bifocal design concept has been used to obtain an improved performance for the off-axis beams with respect to the single focused antenna. The required phase-shift distributions are initially obtained with the reflectarrays in parallel planes, and then adjusted to compensate the tilting of both reflectarrays in the final Cassegrain configuration. The simulated radiation patterns in the elevation and azimuth orthogonal planes have been calculated for the two beams generated by the focuses, and then the multi-beam performance of the antenna has been evaluated.

TOP

W_P01 Vehicular channels

Wireless Networks / Regular Session / Propagation
Oral Sessions: Room 341
Chairs: Philippe Besnier (IETR, France), Davy P Gaillot (University of Lille 1, France)

16:50 ***Polarimetric Ground-to-Ground and Ground-to-Air Channel Characterization in Forest Environment***
Pierre Laly (University of Lille, France); Davy P Gaillot (University of Lille 1, France); Martine Liénard (University of Lille, France); Jean-marie Floch (IETR-INSA Rennes, France); Rose Mazari

and Pierre Degauque (University of Lille, France); Guy Grunfelder (IETR-INSA De Rennes, France)

The precise localization of an injured person in a forest environment can be made owing to his cell phone by deploying a dedicated direction finding equipment in the search zone and placed onboard either a vehicle or a drone. The localization accuracy being strongly dependent on the propagation channel characteristics, measurements have been carried out with a MIMO channel sounder at a center frequency of 1.35 GHz and with an 80 MHz bandwidth. Each array element is a dual-polarized patch antenna allowing a multidimensional polarimetric estimation of the channel. The receiving array is below or over the canopy when onboard a vehicle or at different altitudes when onboard a drone. Path loss, delay spread and coherence bandwidth are studied for different relative orientations of the antennas, including co- and cross-polarization configurations. Directions of arrival of the rays are deduced from the MIMO matrix owing to a high resolution algorithm.

17:10 ***Simulation of V2V Communications in Various Propagation Channels: Assessing Antenna Performance in Terms of PER***

Jessen Narrainen (IETR - INSA de Rennes & Renault SAS, France); Philippe Besnier (IETR, France); Philippe Boutier (Renault sas, France)

In this paper, we present a simple and complete simulation approach to compare antenna performance within the frame of Vehicle-to-Vehicle (V2V) communication systems. A geometry-based stochastic channel model (GBSCM) is used to simulate propagation channel pertaining to main environments in a V2V context. Once propagation scenarios are simulated, they are combined with the integration of various antenna locations and patterns. Finally, their performance can be analyzed in terms of Bit Error Rate (BER) or Packet Error Rate (PER) after the implementation of the physical layer (PHY layer) following the IEEE 802.11p standard dedicated to V2X communications.

17:30 ***Cluster-Based Radio Channel Emulation for Over-the-Air Testing of Automotive Wireless Systems***

Philipp Berlt, Frank Wollenschläger and Christian Bornkessel (Technische Universität Ilmenau, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

More and more radio systems are incorporated in modern automobiles e.g. multiple mobile communication standards for car-to-car or car-to-infrastructure communications like LTE, ITS G5, satellite navigation, radar detection, and so on. These complex systems need to be tested extensively and under realistic conditions. This paper discusses a modular approach for antenna constellations for over-the-air tests in the virtual road simulation and test area (VISTA) of the Thuringian Center of Innovation in Mobility at the Technische Universität Ilmenau. The goal is to reproduce multipath clusters, in terms of the angular spread of arrival and, as a consequence, the spatial correlation of received signals, as a key parameter of mobile communication channels. This paper amplifies the scope of current research on modular antenna configurations and analyzes the influence of array design parameters on the spatial correlation and, hence, on their suitability for reliable channel emulation.

17:50 ***RCS Modeling and Measurements for Automotive Radar Applications in the W Band***

Emna Bel Kamel and Alain Peden (Telecom Bretagne, France); Patrice Pajusco (TELECOM Bretagne, France)

This paper describes a reliable methodology for radar cross section (RCS) measurement of complex small and large targets in the W band. The backscattering behavior of a small car model was measured in an anechoic chamber along with various automotive related targets in a wide gymnasium. Experimental performance in the anechoic chamber is compared to the simulation results. Our simulation model is based on deterministic scattering centers, determined by high frequency approaches, like the physical optics (PO) and the physical theory of diffraction (PTD). Nevertheless, simulations of realistic large objects are both time consuming and difficult to implement. The proposed measurement configuration enables the extraction of non-predetermined scattering points for large object modeling which will significantly decrease the simulation time for road scenarios in radar applications.

18:10 ***A New Method for Evaluation of LTE MIMO Antennas in Automotive Application***

Mahmoud Almarashli (Universität der Bundeswehr München, Germany); Stefan Lindenmeier (Universität der Bundeswehr, Germany)

For the LTE standard using multiple-input multiple-output (MIMO) radio-access technology, there is a high challenge to evaluate car antennas appropriately, taking into account the antenna environment formed by the car body in the MIMO channel. New statistical methods are required on base of the propagation properties of antennas which are integrated close to each other in a reflecting and refracting environment. In this contribution we present an evaluation method of LTE-car antennas, which enables the analysis of virtual drives. The test drives are performed via simulation of driving paths in urban or rural environments with ray-tracing, while the description of the receiving part is given via the complete information of the complex antenna characteristics of the coupled antennas which are measured on a real car. An example with two realized antenna modules is analyzed by this method and the results are compared to results from real drives.

TOP

C_P02 Indoor Propagation

Cellular Communications / Regular Session / Propagation

Oral Sessions: Room 342A

Chairs: Iñigo Cuiñas (University of Vigo, Spain), Wout Joseph (Ghent University/IMEC, Belgium)

16:50 ***Characterization of Wireless Propagation Through Traditional Iberian Brick Walls***

David Ferreira (University of Vigo & Instituto de Telecomunicações, Portugal); Telmo R.

Fernandes (IPLeiria / Institute of Telecommunications & ESTG/IT-DL, Portugal); Rafael F. S. Caldeirinha (IPL - Polytechnic Institute of Leiria & Instituto de Telecomunicação (IT), Portugal); Iñigo Cuiñas (University of Vigo, Spain)

This paper presents the wireless transmission properties for brick walls with different thicknesses and facade finish coatings. The ceramic hollowed bricks under study are traditionally employed in the Iberian residential construction, where the 11, 15 and 20 cm thicknesses are most common in indoor and outdoor walls. For each brick dimension, three different prototypes were manufactured varying in the type of wall finish, i.e.: naked brick, smooth painted plaster and rough painted plaster. The prototypes were measured in an anechoic chamber at frequencies ranging from 680MHz up to 10GHz. Results demonstrate that the brick wall internal heterogeneity, as well as the type of finish, significantly influence the frequency response of the walls.

17:10 ***Channel Estimation Using Spherical-wave Model for Indoor LoS and Obstructed LoS Scenarios***

Yilin Ji, Wei Fan and Gert Pedersen (Aalborg University, Denmark)

When the array apeture increases to a huge extent (e.g. tens to hundreds of wavelengths), and the distances between transmitter, scatterers, and receiver are small, conventional plane-wave model cannot be used to characterize the impinging wave accurately anymore. To avoid model mismatch during estimation, in this paper, we use spherical-wave model as the generic signal model, and estimate parameters of multipath component (MPC) with a maximum likelihood method for indoor line-of-sight (LoS) and Obstructed LoS (OLoS) scenarios. The estimated MPCs are reconstructed in the physical environment using a simple geometric method. Comparison with plane-wave model was also conducted to investigate the necessarity of spherical-wave model.

17:30 ***Polarimetric Properties of Indoor MIMO Channels for Different Floor Levels in a Residential House***

Sunil Raut Kshetri (Ghent University & Imec, Belgium); Emmeric Tanghe (Ghent University, Belgium); Davy P Gaillot (University of Lille 1, France); Martine Liénard (University of Lille, France); Luc Martens (Ghent University, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

This paper analyzes polarimetric characteristics of power delay profiles, cross polarization discrimination (XPD), and received power of specular and diffuse multipath components of MIMO radio channels at 2.45 GHz. Measurements were done in a residential house at two floors levels: ``same floor'' and ``cross floor''. Variations of 5 to 15~dB in PDPs between co-and cross-polar links were found in the same floor level; however these changes decrease as links go from line-of-sight to non-line-of-sight. XPDs of the radio waves were found to be higher for the cross floor configuration, about 5~dB in horizontally and 7~dB in vertically polarized waves. Also, diffuse components of the radio channels were less affected in cross-polar subchannels compared to that of specular components in the same floor level. The results demonstrate the contribution of diffuse components to the total channel power is higher than previously presented studies for indoor environments.

17:50 ***Doppler Characteristics for Indoor Mobile-to-Mobile Channels***

Gloria Makhoul (CEA-LETI & ICTEAM Electrical Engineering, Université Catholique de Louvain (UCL), France); Francesco Mani (Università degli studi di Bologna, Italy); Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France); Claude Oestges (Université Catholique de Louvain, Belgium)

This paper analyzes Doppler spectra of mobile-to-mobile (M2M) channels, based on a measurement campaign carried out in an indoor environment at 2.48 GHz. The Doppler spectra are characterized in line-of-sight (LOS) and non-line-of-sight (NLOS) environments for different types of pedestrian movements. Subsequently, an analytical Doppler spectrum model is proposed and successfully compared to the measurement data.

18:10 ***Measurement and Modeling of 3-Dimensional Radio Channels with Cross-Polarizations in a Gymnasium***

Zhimeng Zhong (Huawei Technologies Co., Ltd., P.R. China); Ruonan Zhang, Kaijun Ren and Kun Wang (Northwestern Polytechnical University, P.R. China); Bin Li (Northwesten Polytechnical University, P.R. China); Xiaomei Zhang (Huawei, P.R. China)

Directional beamforming can increase the network capacity significantly with spatial multiplexing, especially for the hot spots such as airport, shopping malls, and stadiums. Accurate characterization and models of the spatial propagation in such indoor environments are required. In this paper, a 3-dimensional MIMO channel measurement campaign in a large gymnasium is presented. A wideband sounder equipped with two dual-polarized crossed linear arrays was used and the transceivers were placed at different positions on the stands. The azimuth and elevation power spectrum and root-mean-square angular spread of arrival (ASA/ESA) of the multipath components were measured. The normal and lognormal distribution models are proposed for the angular power spectra and angular spreads, respectively. Finally it is demonstrated that the angular spreads have no tendency with respect to the transceiver positions. The measurement results can support the design of the directional transmission technologies for spatial multiplexing in indoor hot-spot scenarios.

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CS50 Wireless Sensors for Medical Applications: from Wearables to Implants

Biomedical / Convened Session / Antennas

Oral Sessions: Room 342B

Chairs: Konstantina Nikita (National Technical University of Athens, Greece), Raed Shubair (Khalifa University (KU) & Massachusetts Institute of Technology (MIT), United Arab Emirates (UAE))

16:50 ***Wireless Sensors for Medical Applications: Current Status and Future Challenges***

Hadeel Elayan (Khalifa University, United Arab Emirates (UAE)); Raed Shubair (Khalifa University (KU) & Massachusetts Institute of Technology (MIT), United Arab Emirates (UAE)); Asimina Kiourti (The Ohio State University, USA)

Continuous health monitoring using wireless body area networks of implantable and wearable medical devices is envisioned as a transformative approach to healthcare. Rapid advances in biomedical sensors, low-power electronics, and wireless communications have brought this vision to the verge of reality. However, key challenges still remain to be addressed. This paper surveys the current state-of-the-art in the area of wireless sensors for medical applications. It focuses on presenting the recent advancements in both wearable and implantable technologies. Furthermore, this paper addresses the challenges that exist in the various Open Systems Interconnection (OSI) layers and illustrates future research areas concerning the utilization of wireless sensors in healthcare applications.

17:10 ***A Polarization/Frequency Interchangeable Patch for A Modular Wearable Textile Antenna***

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)

A concept of modular textile antennas based on commercial snap-on buttons has been recently proposed for wearable applications. This concept has been demonstrated to provide passive system reconfigurabilities in resonance frequency, polarization and/or radiation characteristics using a common feeding structure as a base. In this paper, as a further illustration of the versatility of the modular concept, a circular patch module with a rectangular flap cut in the middle is proposed. This module can provide interchangeability between right-handed circular polarization (RHCP), left-handed circular polarization (LHCP) and linear polarization (LP), as well as passive reconfigurability in resonance frequency for LP, through simple module rotation and different flap configurations (opened or closed).

17:30 ***Performance Evaluation and Sensitivity Analysis of a Novel Rectenna System for Deep Implanted Devices***

Sofia Bakogianni, Mihalis Palaiologos and Stavros Koulouridis (University of Patras, Greece)

We examine the performance of an implantable antenna combined with a rectifier circuit (Rectenna) in terms of polarization stability, effect of surrounding tissue electrical properties and implantation depth. A single-layer Planar Inverted F-Antenna (PIFA) that exhibits dual-resonance for data telemetry (MedRadio band, 402 MHz) and power transfer (ISM band, 915 MHz) is employed. Antenna polarization is investigated through axial ratio computations. Further, we consider nine tissue-dielectric scenarios comprising ±5% and ±10% variations in the initial tissue permittivity and conductivity. Subsequently, the antenna implantation depth is, also, altered. Indeed, proposed implantable antenna is robust with regards to reliability of wireless link, resonance response and radiation performance. Finally, an improved, previously presented, rectifier system is presented. As shown, its efficiency reaches almost 40% (20% increase) for an optimum load RL=9.5 kOhm at a reference power level Pr=-16 dBm.

17:50 ***Energy Harvesting and Cardiovascular Monitoring Through Arterial Wall Pulsation***

Grigorios Marios Karageorgos, Christos Manopoulos, Socrates Tsangaris and Konstantina Nikita (National Technical University of Athens, Greece)

In this paper, we present an optimized design of an energy harvesting device that converts the arterial wall pulsation to electrical energy and we demonstrate its feasibility to function as a sensor for cardiovascular system monitoring. The device is based on electromagnetic induction and is composed of a coil that pulsates with the artery inside the magnetic field produced by two permanent magnets. In order to validate the proposed concept and evaluate the device's performance, an experimental setup that mimics blood flow and arterial wall movement was constructed. In-vitro experiments indicated that proper optimization can increase the device's produced power and voltage, and that the output voltage of the coil is associated with heart rate, blood pressure, arterial wall velocity and deformation.

18:10 ***Bio-degradable Material for Short Term Implants***

Max Munoz and Emiliano Bilotti (Queen Mary, University of London, United Kingdom); Yang Hao (Queen Mary University, United Kingdom)

The paper presents some preliminary results of electromagnetic characteristics of a layered bio-degradable material. Measurement data demonstrates that the proposed material can be used as a suitable substrate for design and implementation of compact antennas for applications such as low power autonomous sensors and short-term medical implants.

TOP

H_A04 Mm-Wave Antennas for High Data Rate II

High Data-rate Transfer / Regular Session / Antennas

Oral Sessions: Room 343

Chairs: Nima Ghalichechian (The Ohio State University, USA), Dirk Manteuffel (University of Hannover, Germany)

16:50 ***An Improved Millimeter-Wave Bull's Eye Antenna***

Konstantinos Konstantinidis (University of Birmingham, United Kingdom); Despoina Kampouridou (University of Birmingham, UK); Marina Mavridou and Alexandros Feresidis

(University of Birmingham, United Kingdom)
In this paper, an improved mm-wave Bull's eye antenna is proposed. The structure is formed by concentric periodic rings etched of a metallic plane. The antenna is designed to produce high-gain radiation patterns with broadband operation around 14 GHz. A novel feeding technique is introduced yielding a broadband input matching performance. The antenna has been simulated using CST Microwave StudioTM, achieving a maximum gain of 15.8 dB and 3 dB bandwidth of 17%. A prototype has been fabricated and the results will be presented.

17:10 ***High Aperture Efficiency Bull's-Eye Antenna***
Unai Beaskoetxea (Universidad Pública de Navarra, Spain); Miguel Beruete (Universidad Publica de Navarra, Spain)
A 60 GHz operating Bull's-Eye (BE) antenna with wide corrugations and a soft-surface is numerically and experimentally analyzed. The employment of wide grooves, rather than narrow grooves, allows a high enhancement of the gain, whereas the inclusion of the soft surface, reduces the side lobe level as well as the backward radiation. A BE with narrow corrugations was also simulated for the purpose of comparison. Fabricated antenna shows a gain of 20.3dB which, due to its reduced dimensions, corresponds to a high aperture efficiency ea = 32%. Furthermore, -13.2 dB side lobe level and 10.4 deg beamwidth are observed.

17:30 ***Additive Manufactured Millimeter Wave Off-Axis Bull's-Eye Antenna***
Unai Beaskoetxea (Universidad Pública de Navarra, Spain); Stefano Maci (University of Siena, Italy); Miguel Navarro-Cía (University of Birmingham, United Kingdom); Miguel Beruete (Universidad Publica de Navarra, Spain)
Despite their low profile and competitive radiation characteristics, most of the devices in the corrugated leaky wave antenna family feature an unnecessary excess weight which result detrimental for current innovative applications, such as unmanned aerial vehicles (UAV), aircrafts or satellite antennas. Stereolitography, accompanied by plating, is presented as an economic and fast solution for the manufacturing of lightweight devices, which at the same time is able to overcome traditional metal drilling/spark erosion manufacturing limitations. Here we present an elliptical Bull's-Eye antenna operating at 96 GHz fabricated following a 3D-printing and copper coating process. Due to the off-centered grooves, a tilted beam pointing at 16.5º is obtained, presenting a gain of 17 dB and 3.5 beamwidth.This prototype results of interest for point-to-point communications where direct front side view is not possible, as well as for applications where lightweight and cost-effective antennas are needed, such as satellite communications or deployed in UAV's.

17:50 ***60 GHz 3D Integrated Waveguide Fed Antennas Using Laser Direct Structuring Technology***
Aline Friedrich (Leibniz Universität Hannover, Germany); Malte Fengler (LPKF Laser & Electronics AG, Germany); Bernd Geck (Leibniz Universität Hannover, Germany); Dirk Manteuffel (University of Hannover, Germany)
The following contribution presents the design of waveguide fed antennas that are directly integrable into injection molded plastic parts using 3D molded interconnect devices technology. The fabrication method used for 3D metallization of the plastic parts is Laser Direct Structuring (LDS). First a single dielectric filled waveguide fed horn antenna is developed, fabricated and characterized to verify the LDS process. The results show a good match between simulated and measured data proving the principle suitability of the LDS process. Based on this the approach of integrating this type of antenna directly into plastic parts is discussed. As an example a dielectric horn antenna is integrated into a generic plastic part and evaluated based on field simulations. The antenna is developed to operate in the frequency range of the WiFi IEEE 802.11ad standard.

18:10 ***60 GHz Capacitively Probe-Fed Patch Arrays with Suspended Elements***
Kaveh Keshtkaran (The Ohio State University & Electroscience Laboratory, USA); Nima Ghalichechian (The Ohio State University, USA)
A major drawback of current millimeter wave technologies used for integration of phased arrays on a chip is low efficiency (5-10%) and consequently low realized gain. In this work, we present integrated antenna arrays on silicon that exhibit radiation efficiency of >80% at 60 GHz. This is achieved by suspending the radiating elements of a phased array in air using micro-electro-mechanical (MEMS) processes, effectively replacing a lossy silicon substrate (under each element) with air. In the latest design we used capacitive feeding with pin and patch height of 40 and 60 µm, respectively. Finite element simulation results verify the performance of the array. A finite array with 5×5 elements achieved -10-dB bandwidth of 1.7 GHz. Array is well matched at 60 GHz with S11<−19 dB. Maximum realized gain (at broadside) is 20 dBi with sidelobe level of -13.3 dB. The efficiency is calculated to be 89%.

TOP

CS40 Radiation Control Techniques for Small Antennas

Future Applications / Convened Session / Antennas
Oral Sessions: Room 351
Chairs: Christophe Delaveaud (CEA-LETI, France), Richard W. Ziolkowski (University of Arizona, USA)

16:50 ***Meta-atom Based Dielectric Ferrite Antennas for 3D Printing***
J (Yiannis) Vardaxoglou (Loughborough University, United Kingdom)
This paper examines the effect of the dielectric and magnetic properties of meta-atom artificial materials and how these properties affect the overall performance of small antennas. These structures could be manufactured with 3D printing.

17:10 ***Non-Foster Impedance Design Techniques for High Performance Small Antenna***

Deepak Nagarkoti and Khalid Z Rajab (Queen Mary University of London, United Kingdom); Yang Hao (Queen Mary University, United Kingdom)

The non-Foster impedance circuits enhance the bandwidth performance of small antennas. This paper explores various conventional and novel techniques to realise non-Foster impedance and conclude their advantages as well as limitations. These design techniques includes conventional operational amplifiers (op-amps) and bipolar junction transistors (BJTs) and non-conventional graphene field-effect transistors (GFETs) and resonant tunnelling diodes (RTDs). This paper facilitate the designer to select the appropriate non-Foster circuit (NFC) for broadband matching of antenna.

17:30 ***Decoupling Approach of Superdirective Antenna Arrays***

Abdullah Haskou (IETR UMR CNRS 6164, Université de Rennes1, France); Ala Sharaiha (Université de Rennes 1 & IETR, France); Sylvain Collardey (University of Rennes 1, France)

The inter-element distance in superdirective arrays is usually very small and hence the mutual coupling is considerably high. Consequently, these arrays present relatively low efficiencies. In this paper, we propose using decoupling techniques for reducing the mutual coupling, and hence increasing the efficiency, in this kind of arrays. The concept is proven by full wave simulations of two different Electrically Small Antenna (ESA)-based two-element arrays with an inter-element distance of 0.1λ. In the first array with a ka = 0.56, the original (before decoupling) radiation efficiency of 7% is increased to 13.4% and the realized gain is increased from −6.4dBi to −2.6dBi. In the second array with a ka = 1.18, the original radiation efficiency of 52.1% is increased to 63.7% and the realized gain is increased from 3dBi to 3.9dBi.

17:50 ***Superdirective Radiation of Arrays of Thin-Wire Nanoloops***

Mario F Pantoja (University of Granada, Spain); Jogender Nagar and Bingqian Lu (The Pennsylvania State University, USA); Douglas H Werner (Pennsylvania State University, USA)

Superdirective radiation is one of the most challenging and elusive problems in electromagnetics because of its inherent drawbacks, such as the narrowband and extreme sensitivity. However, there is a renewed research interest on the superdirectivity problem to solve the problem of the short-range communications of nanodevices. This contribution presents recent advances based on arrays of thin-wire nanoloops, aimed to explore the possibilities of these structures as seed of nanodevices which can bring to the reality a wideband, superdirective radiation patterns at the terahertz and infrared regimes. Potential applications are remote sensing, wireless communications and nanoelectronics.

18:10 ***Implementation of a THz Quasi-Spiral Antenna for THz-IR Detector***

Alicia E. Torres-García (Public University of Navarra, Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain); Ramon Gonzalo (Public University of Navarra, Spain)

A sub-millimeter quasi-spiral antenna based on a modified Fresnel Zone Plate Lens (FZPL) for the IR range is proposed. The design is part of an integrated receiver, which consists of a Si (silicon) slab where two detector configurations will be printed working at infrared (IR) and sub-millimeter range simultaneously. Various modifications of spiral antennas are evaluated to act as a sub-millimeter wave antenna (operating at 700 μm) and as a modified Fresnel Zone Plate Lens in the Mid-IR range (around 10.6 μm). The design, optimization and fabrication process for the quasi-spiral antenna with the best performance for both functions are presented.

TOP

R_P02 Radar Systems

Radars / Regular Session / Propagation

Oral Sessions: Room 352A

Chair: Jochen Moll (Goethe University Frankfurt am Main, Germany)

16:50 ***Calibration of a Fully Polarimetric 8x8 MIMO FMCW Radar System at 77 GHz***

Tristan Visentin and Juergen Hasch (Robert Bosch GmbH, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)

State-of-the-art millimeter wave (MMW) multiple-input, multiple-output (MIMO) frequency-modulated continuous-wave (FMCW) radars allow high precision direction of arrival (DOA) estimation with an optimized antenna aperture size [1]. Typically, these systems operate using a single polarization. Fully polarimetric radars on the other hand are used to obtain the polarimetric scattering matrix (S-matrix) and extract polarimetric scattering information that otherwise remains concealed [2]. Combining both approaches by assembly of a dual-polarized waveguide antenna and a 77GHz MIMO FMCW radar system results in the fully polarimetric MIMO radar system presented in this paper. By applying a MIMO-adapted version of the isolated antenna calibration technique (IACT) from [3], the radar system is calibrated and laboratory measurements of different canonical objects such as spheres, plates, dihedrals and trihedrals are performed. A statistical evaluation of these measurement results demonstrates the usability of the approach and shows that basic polarimetric scattering phenomena are reliably identified.

17:10 ***Activity Monitoring of Bats in a Laboratory Flight Tunnel Using a 24 GHz FMCW Radar System***

Jochen Moll and Moritz Mälzer (Goethe University Frankfurt am Main, Germany); Viktor Krozer (Goethe University of Frankfurt am Main, Germany); Dimitry Pozdniakov (HF Systems Engineering GmbH & Co. KG, Germany); Rahmi Salman (HF Systems Engineering GmbH & Co. KG & Hübner Holding GmbH, Germany); M. Jerome Beetz and Manfred Kössl (Goethe University Frankfurt am Main, Germany)

Radar techniques have been used recently to monitor bats when they are hunting close to wind energy plants.

However, the real-time detection of bats is a challenge and activity metrics must be defined that enable a robust bat detection. In this paper we report on FMCW radar measurements at 24 GHz of Seba's short-tailed fruit bats (Carollia perspicillata) in a laboratory flight tunnel. Experiments have been performed with a single flying bat and multiple simultaneously flying bats. We introduce several activity metrics and discuss their properties. Further signal processing results, such as Range-Doppler maps, will be presented and discussed.

17:30 ***Multipath Estimation Technique for Wideband mm-Wave Backscattering Channels***

Francesco Guidi (CEA LETI, France); Antonio Clemente (CEA-LETI Minatec, France); Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

In this paper we describe a method to discriminate multipath components in joint angular and temporal domain by exploiting the a-priori knowledge of the antennas characteristics into an ad-hoc algorithm for wideband backscattering channels. By means of two indoor measurement campaigns performed using millimeter-waves massive arrays in a corridor and in an office room, we show the feasibility of the proposed approach and we compared its performance to those of methods already available in the state of the art.

17:50 ***Experimental Comparison of Localisation Techniques in the Presence of Array Uncertainties***

Qinxin Liu and Athanassios Manikas (Imperial College London, United Kingdom)

In this paper, the performance of two source localization (range and azimuth) approaches are studied experimentally using multiple off-the-shelf Universal Software Radio Peripheral (USRP) hardware boards forming a circular antenna array of nine elements operating in the presence of a source located in the near-far field of the array. In particular, the effects of gain and phase array uncertainties on these localization approaches are presented and their experimental accuracy is examined in terms of both range and direction RMSE.

18:10 ***A Novel Processing Algorithm for Multiple Elevation Beam SAR Systems***

Taoli Yang (UESTC, P.R. China); Donglin Li (Shanghai Institute of Satellite Engineering, P.R. China)

A novel processing algorithm for multiple elevation beam (MEB) synthetic aperture radar (SAR) systems is presented. MEB SAR is a promising technique to reduce the onboard data amount, and its key processing procedure is subpulse separation which is affected by the topography. In this paper, the echoes received by multiple elevation channels (MEC) are regarded as signals coming from different direction-of-arrive (DOA) angles. Then, the subpulse separation is transformed to DOA estimation. Considering the sparsity of the received signals in spatial domain, the sparse-based DOA estimation algorithm is adopted. After obtaining the DOA angles, the overlapped subpulses are separated. The algorithm can also be applied to other MEC SAR systems. Finally, the effectiveness of the proposed algorithm is confirmed in simulations.

TOP

L_A01 Antenna sensors

Localization & Connected Objects / Regular Session / Antennas

Oral Sessions: Room 352B

Chairs: Etienne Perret (Grenoble INP - LCIS, France), Patrizia Savi (Politecnico di Torino, Italy)

16:50 ***Wireless Monitoring of Breath by Means of a Graphene Oxide-based Radiofrequency Identification Wearable Sensor***

Maria Cristina Caccami and Mohammad Yusuf Shafi Mulla (University of Rome "Tor Vergata", Italy); Corrado Di Natale (Università di Roma Tor Vergata, Italy); Gaetano Marrocco (University of Rome "Tor Vergata", Italy)

The monitoring of the breathing dynamic characteristics, including the presence of biomarkers in exhaled breath, is of growing interest in noninvasive diagnosis of diseases. We describe a wearable radiofrequency identification (RFID) device hosting a flexible antenna suitable for integration into a facemask and a sensor made of graphene oxide sensitive to the humidity variations. The so obtained wearable wireless sensor was characterized in reference conditions and was then experimentally demonstrated to be capable of detecting the inhalation/exhalation cycles and abnormal patterns of respiration like the apnea by measuring the changes in graphene oxide resistance.

17:10 ***RFID Helix Antenna on Power Cord for the Sensing of Home Electrical Devices Activity***

Rupesh Kumar, II (Technicolor & Research & Innnovation, France); Ali Louzir and Jean-Yves Le Naour (Technicolor, France)

a flexible RFID-Helix antenna wrapped around the power-cord, integrated with a RFID tag and a current impulse detection circuit, for wireless sensing of the activity of home electrical devices, is proposed. While the use of a straight dipole showed a significant distortion of the antenna radiation pattern due to the very close proximity of the wires inside the power cord, the use of a helical dipole reduces significantly the coupling to the power cord. Furthermore, the antenna coupling to the impulse current arising at the switch ON/OFF of the electrical device, required by the application, is improved and the overall size of the antenna reduced. A realized prototype of the impulse sensing RFID tag using the designed helix-dipole antenna wrapped around the cord demonstrated a sensing range of 7-8 m with a standard RFID reader operating in the US 915 MHz RFID band.

17:30 ***Potential of Chipless Authentication Based on Randomness Inherent in Fabrication Process for RF and THz***

Zeshan Ali (Grenoble INP - LCIS); Florent Bonnefoy (University of Savoie Mont Blanc, IMEP-LAHC, France); Romain Siragusa (Grenoble INP - LCIS); Nicolas Barbot, David Hély and Etienne Perret (Grenoble INP - LCIS, France); Maxime Bernier and Frédéric Garet (University of Savoie

Mont Blanc, IMEP-LAHC, France)
In this paper, two chipless solutions dedicated to the authentication of manufactured products are proposed. One device is operating in the RF domain while the other used terahertz (THz) waves. The concept of chipless RFID is extended to authentication where each tag has to present a unique signature that can never be reproduced even if someone try to copy the tag. Both approaches use Electromagnetic (EM) wave as a tool for non-invasive and non-destructive authentication of items. The results show that it is possible to discriminate RF, respectively THz, signatures obtained from devices whose differences of geometrical parameters are as small as tens of micrometers, respectively several micrometers in the THz domain.

17:50 ***Design of a Graphene-Loaded Slotted Ring Resonator for Sensor Applications***
Patrizia Savi (Politecnico di Torino, Italy)
Graphene is a monolayer of carbon atoms with remarkable electronic and mechanical properties amenable to sensor applications. While the plasmonic nature of graphene at terahertz frequency has been widely reported, investigations on the practical utility of graphene at the microwave frequencies used in wireless sensor nodes are sparse. In this paper, a printed RF slot ring resonator is configured with a graphene thin-film for sensor application. The graphene sensing element comprising the slot ring can be integrated with control electronics as a passive wireless sensor node, but the sensor aspect is not addressed in this paper. The novelty of the paper is that RF losses are minimized by capacitively loading the ring at selective locations along its periphery. Dielectric spectroscopy is used to study variation in surface impedance of the film for various graphene loadings, and RF simulations are corroborated with measurements on graphene loaded slot ring resonators.

18:10 ***An Electromagnetic Sensing System Incorporating Multiple Probes and Single Antenna for Wireless Structural Health Monitoring***
Burak Ozbey and Ayhan Altintas (Bilkent University, Turkey); Hilmi Volkan Demir (Nanyang Technological University, Singapore); Vakur Erturk (Bilkent University, Turkey); Ozgur Kurc (Middle East Technical University, Turkey)
In this study, a wireless and passive displacement/ strain sensing system is proposed for structural health monitoring (SHM). The wireless and passive interrogation of the sensing unit [a variant of a nested split-ring resonator (NSRR)] is achieved through the near-field interaction and electromagnetic coupling between the single antenna in the system and the multiple sensors called the NSRR probes. It is demonstrated that the system can acquire data from more than one NSRR probe simultaneously in a real-life scenario, where the probes are confined within concrete inside a beam, while the antenna monitors them from outside.

TOP

MT_M01 Advances in Test Range Design

Methods & Tools / Regular Session / Measurements
Oral Sessions: Room 353
Chairs: Bernd Gabler (German Aerospace Center (DLR), Germany), Bengt Svensson (Saab AB, Sweden)

16:50 ***Full-Wave Analysis of a Compact Antenna Test Range Including Probe Effect***
Thomas M Gemmer, Rasmus Cornelius, Joerg Pamp and Dirk Heberling (RWTH Aachen University, Germany)
Simulated Quiet Zone (QZ) performance of a designed Compact Antenna Test Range (CATR) is validated by QZ field probing. Simulations of CATRs, however, lack of modeling the probe. The receiving antenna which is used in order to evaluate the field in the QZ has an influence on the calculated / measured co- and cross-polar components. The degree of the effect depends on the radiation characteristic and on the cross-polarization purity of the probe. Including the probe into simulations overcomes the disadvantages of probe correction since the possibility exists to calculate arbitrary dimensions of the QZ. To determine the extent, three probes are characterized and used during field-probing measurements at a frequency of 4.5 GHz. Subsequently, simulated QZ data is generated using a single-reflector model in combination with the multi-level fast multipole method implemented in FEKO. The measured probe patterns are included into the calculated data by applying planar near-field theory.

17:10 ***Modular Simulation of a Compact Antenna Test Range***
Björn Möhring, Markus Limbach, Bernd Gabler and Alberto Di Maria (German Aerospace Center (DLR), Germany)
This paper presents a method for the modular simulation of a Compact Antenna Test Range (CATR). The CATR simulated in this work is similar to the installed facility at the Microwaves and Radar Institute at the German Aerospace Center (DLR) in Oberpfaffenhofen and it has a dual reflector configuration. A model of this facility was created and simulated with both full-wave methods such as Method of Moments (MoM) and asymptotic methods such as Iterative Physical Optics (IPO) by means of the software tool Antenna Design Framework (ADF). The implemented method is used to gather insights of the working principle of this chamber, to provide data in order to judge real obtained measurement results, and to draw out weaknesses of this CATR.

17:30 ***Measurement of a Large Radome at an Antenna Compact Test Range***
Bengt Svensson (Saab AB, Sweden); Bjorn Widenberg (GKN Aerospace Applied Composites, Sweden); Mattias Viberg (Saab AB, Sweden)
A 5 m SATCOM radome has been measured at the Saab A15 compact test range. The modifications of the test range, such as including the gimbal axes in the measurement system, are described. Furthermore, different measurement considerations, due to the large sized radome, are discussed and highlighted. Some typical results are also shown. The range was found to have very small drift and excellent repeatability.

17:50 ***A New Compact Antenna Test Range for EW-Antenna System Production Testing***

Bengt Svensson and Rikard Gustafsson (Saab AB, Sweden); Peter Hultman (Saab Electronic Defence Systems, Sweden); Per-Åke Hansson and Christian Augustsson (Saab AB, Sweden); Anders Jernberg (MVG Seden); Carsten Seupel (Orbit/FR, Sweden)

A new Compact Antenna Test Range, for EW-antenna system production measurements, is presented. The test object is an active, complex antenna system with several low-gain elements as well as an AESA. The focus in the design of the range was to be able to handle efficient production measurements for this advanced, broadband, test object. To facilitate this, the range is highly automated, which makes it possible to measure several frequency bands, Tx/Rx mode, and test object states in an automated sequence. Test object access and handling was also a key parameter in the range design. Special care was taken to minimize disturbances from the turn tables by recessing the azimuth and slide positioners in a pit in the floor. This is especially important for accurate measurements and interferometry calibration of the low-gain antenna elements.

18:10 ***Design, Fabrication and On-site Alignment of Low-cost Reflector Used in Large-scale Compact Antenna Test Range***

Wang Mingming, Li Dongsheng, Zhou Xianbin and He Guoyu (Beihang University, P.R. China)

A low-cost reflector used in large-scale compact antenna test range (CATR) with Φ6.0m quiet zone and 0.5~110GHz operating frequency is developed. Firstly, the geometry dimension, dividing scheme and structure form of the reflector are designed according to electrical requirements. Then, vacuum forming based on reconfigurable discrete nail mould (RDNM) is developed to rapidly and low-costly manufacture high-accuracy reflector with honeycomb sandwich structure. Due to extra-large area, the whole reflector is divided into many small panels to be fabricated separately. Meanwhile, steel framework and adjustment mechanism are designed to install and adjust all these panels. Then, a closed-loop adjustment system is constructed by adjustment mechanism and commercial laser tracker to adjust and align all these panels on site. Through final alignment, the root mean square (RMS) of surface error of the whole reflector comes up to 28?m.

F_A02 MetaSurfaces I

TOP

Future Applications / Regular Session / Antennas

Oral Sessions: Room 362/363

Chairs: Giuseppe Di Massa (University of Calabria, Italy), Bertrand Etchessahar (CEA, France)

16:50 ***RCS of Targets with Plasmonic Coatings: Computation, Additive Manufacturing and Measurement***

Genevieve Maze-Merceur, Carol Saint-Flour and Bertrand Etchessahar (CEA, France); Fabien Degery (CEA-DAM, France); Pierre Massaloux (CESTA, France); Olivier Vacus (CEA-DAM, France)

Plasmonic coatings could be a solution to the design of stealthy targets over the microwave range. In this communication, Perfectly Electrically Conducting spheres with plasmonic coatings are studied. Two main issues are raised. As the exact computation of the Radar Cross Section (RCS) of finely textured targets with overall dimensions greater than the wavelength of interest often leads to high CPU time consumption, an effective medium approximation correctly describing the electromagnetic behaviour of the coating is suggested. The resulting approximated RCS computations are in good agreement with the exact full wave solution over a broad range of microwave frequencies. Afterwards, a textured spherical metallic target was designed and manufactured. Relying on computer-aided additive manufacturing, a periodically grooved metallic sphere has been realized successfully. Eventually, as we shall see, experimental RCS measurements of a periodically grooved metal sphere and the corresponding theoretical computations compare fairly well.

17:10 ***Tunable Water-based Microwave Metasurface***

Polina Kapitanova (ITMO University, Russia); Mikhail Odit (National Research University of Information Technologies, Russia); Dmitry Dobrykh (Dep. of Nanophotonics and Metamaterials, ITMO University, Greece); Andrei Andryieuski (Technical University of Denmark, Greece); Andrei Lavrinenko (Technical University of Denmark, Denmark); Pavel Belov (ITMO University, Russia)

A water-based dynamically tunable microwave metasurface is developed and experimentally investigated. A simple approach to tune the metasurface properties by changing the shape of water-based unit cells by gravitation force is proposed. The transmission spectra of the metasurface for linear and circular polarizations of the incident wave are numerically simulated and experimentally measured under the metasurface rotation around a horizontal axis. The measured changes of the transmission coefficient magnitude up to 8 dB at 1.25 GHz are reported while rotating the metasurface by the 90 degree angle. The proposed approach can be used to design cheap metasurfaces for electromagnetic wave control in the microwave frequency range.

17:30 ***Decoupling of Dipole Antenna Array on Patch Type Meta-Surface with Parasitic Cells***

Yuki Kawakami (National Institute of Technplogy, Fukui College, Japan); Ryuji Kuse, Toshikazu Hori and Mitoshi Fujimoto (University of Fukui, Japan)

A low-profile and decoupling dipole antenna array is achieved by combining patch type meta-surface with proposed parasitic cells. Based on the moment method analysis results, it is clarified that proposed parasitic cells can suppress mutual coupling of dipole antennas without additional impedance. In addition, the maximum decoupling effect of 13.3 dB is achieved.

17:50 ***Bianisotropic Huygens' Metasurface Leaky-Wave Antenna with Flexible Design Parameters***

Elena Abdo-Sánchez (University of Málaga & E. T. S. I. Telecomunicación, Spain); Ariel Epstein (Technion - Israel Institute of Technology, Israel); George V. Eleftheriades (University of Toronto, Canada)

We propose a novel leaky-wave antenna configuration which consists of a parallel-plate waveguide with the top plate being a bianisotropic Huygens' metasurface of the omega type. By using closed-form expressions for the metasurface design and after a valid stipulation of the fields below and above it, we are able to design a passive and lossless metasurface that achieves the desired field transformation. The theoretical formulation highlights that we have practically all possible degrees of freedom in the stipulation of the input and output fields. In this way, several examples show that we can arbitrarily choose the output angle, the constant leakage factor and the waveguide height.

18:10 ***Aperture Coupled Circularly Polarized Array Antenna in Ridge Gap Waveguide Technology***

Xingchao Dong (National Space Science Center & University of Chinese Academy of Sciences, P.R. China); Hongjian Wang (National Space Science Center, P.R. China); Fei Xue and Yang Liu (National Space Science Center & University of Chinese Academy of Sciences, P.R. China)

A 4×1 aperture coupled circularly polarized array antenna in ridge gap waveguide technology is presented. The ridge gap waveguide technology is employed to create a desired directional wave propagation. Circular polarization is obtained by introducing L-shaped slot coupling to an oval shaped patch. The simulated results show high circular polarization purity (axial ratio less than 1dB) over the frequency range of 14.58-15.20GHz and the reflection coefficient of better than -10dB over 14.56-15.25GHz band. Gain and radiation patterns of the proposed array antenna are also provided.

TOP

WG_05 ESoA

WG Meetings & Workshops: Room 313/314

Chair: Stefano Maci (University of Siena, Italy)

Thursday, March 23

Thursday, March 23, 08:40 - 12:30

TOP

CS41 Recent Developments in Antenna Technologies for Emerging Satellite Systems

Space / Convened Session / Antennas

Room: Oral Sessions: Auditorium Havane

Chairs: Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France), George Goussetis (Heriot-Watt University, United Kingdom), James Nessel (NASA, USA)

08:40 ***Wideband Multibeam Arrays of Long Slots Fed by Quasi-optical Systems***

Francesco Foglia Manzillo (University of Rennes 1 - IETR, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Thomas Potelon (IETR - University of Rennes 1, France); Maciej Smierzchalski and Ronan Sauleau (University of Rennes 1, France); Nicolas Capet (CNES, France)

This paper summarizes the latest advances on an innovative, broadband multibeam antenna, proposed for satellite communications by the Institute of Electronics and Telecommunications of Rennes (IETR), in the framework of a collaborative research with the French Space Agency (Centre National d'Etudes Spatiales). The antenna comprises an array of long slots, parallel-fed by a corporate feed network of parallel plate waveguides. An integrated quasi-optical beamformer, illuminated by a single horn or by a focal array of horns, excites the feed network. The beam scanning can be achieved both mechanically and electronically. The numerical models developed for the analysis and design are reviewed. The experimental results presented for a Ka-band design demonstrates the wideband, wide-angle scanning performance of the proposed architecture. Finally, future research lines for achieving circular polarization are projected. The proposed antenna concept is particularly suitable for high throughput ground terminals on moving platforms.

09:00 ***Preliminary Design of the NISAR L-Band Feed Antenna Tiles***

Paolo Focardi (Jet Propulsion Laboratory & California Institute of Technology, USA); Paula Brown (JPL, USA)

Being developed in partnership between NASA and the Indian Space Research Organisation (ISRO), the NASA-ISRO Synthetic Aperture Radar (NISAR) satellite is planned to launch in late 2020. NISAR will measure many aspects of how Earth is changing with unprecedented accuracy on a global scale from a Low Earth Orbit (LEO) platform. With a 12m deployable mesh reflector, NISAR will feature one of the largest deployable mesh reflector ever launched for a scientific mission. Two large planar phased arrays will feed the reflector, one that will operate at L-Band and be developed by the Jet Propulsion Laboratory (JPL), and an S-band array that will be developed at the ISRO Space Application Centre (SAC). This paper describes the preliminary design of the L-Band feed array.

09:20 ***A Wide Band Wide Scanning Range Multiple Beam Antenna Based on a Radiating Parallel Plate Waveguide Continuous Delay Lens Beamformer***

Hervé Legay (Thalès Alenia Space, France); Ségolène Tubau, Etienne Girard and Jean Philippe Fraysse (Thales Alenia Space, France); Ronan Sauleau (University of Rennes 1, France); Nelson Fonseca (European Space Agency, The Netherlands)

A novel multiple beam antenna architecture is proposed based on a quasi-optical lens beamformer. It consists in the combination of a doubly curved reflector with a stack of fully metallic parallel plate waveguide beamformers terminated with a flare. It has the capability to reduce the phase aberration over a large angular sector, and thus to improve the characteristics of radiated multiple beams. A novel quasi-optical beamformer based on a continuous delay lens was designed, manufactured and tested. The wide band and wide scanning capability is demonstrated at Ku band. Low return loss and mutual coupling is also achieved for all input ports. The agreement between measurements and simulations is outstanding, for both the S parameters and the radiation patterns. The beamformer was also designed to operate in the Ka- Rx/Tx band. It is of high interest for on-board antennas for LEO and MEO constellation systems.

09:40 ***Planar Wide-Scan Wideband Arrays Based on Connected Slots and Artificial Dielectrics***

Daniele Cavallo, Waqas Hassan Syed and Andrea Neto (Delft University of Technology, The Netherlands)

In this work we present an antenna concept for wideband and wide-scanning phased array applications. The array unit cell consists of a connected-slot element radiating in the presence of a backing reflector and an artificial dielectric superstrate. The artificial dielectrics have anisotropic characteristics that allows to avoid surface waves and scan blindness over a wide scan range and a large frequency band. The design of a dual-polarized array operating in the bandwidth from 7 to 14.5 GHz is presented. Simulated performance show active voltage standing wave ratio (VSWR) lower than 2.5 for scanning up to 60 degrees in the H-plane and 70 degrees in the E-plane. This array is implemented with a single multi-layer printed circuit board, which represents an advantage in terms of cost and complexity, compared to previous connected-array designs.

10:00 ***Circularly Polarised Multiple Beam Antenna for Satellite Applications***

Wenxing Tang (Heriot-Watt University, United Kingdom); Daniele Bresciani (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France); George Goussetis (Heriot-Watt University, United Kingdom); Nelson Fonseca (European Space Agency, The Netherlands)

This paper presents a novel circularly polarised Ku-band multiple beam antenna based on a quasi-optical beamformer and a wideband reflection polarizer conformally deployed along a cylindrical parabolic reflector for satellite applications. By virtue of the wide scanning capability of the beamformer and the wide band and angularly stable response of the curved polarising reflector we demonstrate multibeam capability in circular polarization up to ±18° for a wide Ku band (10-14.5 GHz) with axial ratio below 2 dB. Manufacturing and testing methods are discussed. A breadboard of the multibeam reflector antenna has been fabricated and tested demonstrating very good performance that matches the simulated results.

10:20 Coffee Break

10:50 ***Ground-Based Antenna Array Phasing Issues and Mitigation for Satellite Communications***

James Nessel (NASA, USA)

Communications with satellites in deep space require large antenna aperture systems on the ground in order to receive and transmit data at the power levels necessary to establish a link. However, these large antennas are costly to build and maintain and represent single point failure systems. An alternative to this approach, presently being investigated by NASA, is the use of several smaller aperture antennas combined in an array. The additional difficulty introduced by this approach is the more pronounced impact of atmospheric turbulence which induce phase scintillation errors across the effective aperture of the array. In this paper, the impact of atmospheric-induced phase scintillation on ground based antenna arrays is defined and techniques to mitigate phase scintillation for next generation communications arrays are introduced. A particular focus is made on a novel passive phase scintillation sensing technique utilizing a blind source separation (BSS) approach.

11:10 ***Prediction of Far-Field Pattern Characteristics of Phased Array Fed Reflector Antennas by Modeling Only a Small Part of the Array - Case Study of Spaceborne Radiometer Antennas***

Oleg Iupikov, Artem Roev and Marianna Ivashina (Chalmers University of Technology, Sweden)

In this work we present an approach for the prediction of far-field pattern characteristics of phased array fed reflector antennas by modeling only a small part of the array. In this approach, the simulated EEPs of the FPA are modeled as the phase-shifted versions of the simulated embedded element pattern (EEP) of the central element, and thereafter combined with the optimum weighting coefficients in order to find the total pattern of the feed. Although, the EEPs of dense array antennas are generally not identical (due to the array antenna mutual coupling and edge truncation effects), for typical FPA excitation scenarios, where the array edge elements have relatively low weights to produce the desired illumination of the reflector, this simplified approach has been found sufficiently accurate.

11:30 ***Present State of Antenna Design for X-band SAR Sensor Onboard 100 Kg Class Satellite***

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); Jiro Hirokawa and Dong-Hun Kim (Tokyo Institute of Technology, Japan)

As to realize Synthetic Aperture Radar (SAR) sensor onboard small satellite, a deployable parallel-plate slot array antenna currently has been developed. The propose antenna operates in X-band frequency with vertically polarized radiation. Currently, one antenna panel has been designed by using HFSS simulator. From simulation results, it is expected that antenna with directivity and efficiency of 35.9 dBi and 65.5%, respectively, could be achieved at the center frequency (9.65 GHz).

11:50 ***Shaping of Antenna Reflectors of Flexible Geometries***

Leri Datashvili (Large Space Structures (LSS) GmbH, Germany)

Space telecommunication antenna applications with required in-orbit shape variation ask for morphing skins of antenna reflectors for fulfilment of diverse requirements. Mechanically reconfigurable reflectors can replace the typical configuration of several shaped reflectors and satellites with a single reflector and, thereby, enhance coverage performance to several needed areas of the Earth during a single lifetime in orbit. Thus, their application promises huge cost savings. Design manufacturing and verification of the reflector morphing skin is a challenging task because besides the ability to morph they have to satisfy mechanical and radio frequency stringent requirements. Most challenging mechanical requirement is an amplitude of reshaping in the range of +/- 15 mm maintaining the smoothness of the surface. Material selection and design, tailoring of its properties based on numerical and experimental studies, enhancing radio frequency characteristics and resulting verification of a potential concept of the mechanically reconfigurable reflector are addressed in the paper.

12:10 ***Hybrid Array Fed Reflector Antenna Solution for Broadband Satellite Communications***

Nelson Fonseca (European Space Agency, The Netherlands); Etienne Girard (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France)

An hybrid array fed reflector antenna solution is described in this paper, combining a focused geometry in one plane and an imaging (defocused) geometry in the orthogonal plane. This doubly curved reflector geometry can be combined with a stack of linear phased arrays, introducing some re-configurability at a moderate cost when compared to more conventional imaging reflector solutions using planar phased arrays. A simple analytical formulation is derived to define the proposed doubly curved surface and numerical results are presented for a multiple beam mission at Ka-band. This hybrid antenna solution is considered of interest for broadband payloads to be embarked on future communication satellites.

TOP

CS30 New Trends in Characteristic Modes Research

Wireless Networks / Convened Session / Antennas

Oral Sessions: Room 341

Chairs: Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France), Qi Wu (Beihang University, P.R. China)

08:40 ***Design of MIMO Terminal Antennas with User Proximity Using Characteristic Modes***

Zachary Miers and Buon Kiong Lau (Lund University, Sweden)

Although the classical Theory of Characteristic Modes allows an arbitrary structure to be analyzed prior to the implementation of physical feeds, structures containing dielectrics have so far received very little attention. Recently, a mesh perturbation method is proposed to remove internal resonances from the characteristic mode (CM) solution for lossy dielectrics obtained using the computationally efficient surface integral equation. Herein this method was applied to extract the CMs of a lossy structure consisting of a terminal chassis held in a user hand. These modes were then individually analyzed and a subset was chosen to design a MIMO antenna with not only very low correlation, but also low hand-induced losses.

09:00 ***Low Profile Frequency Agile MIMO Slot Antenna with TCM Characterization***

Asim Ghalib (King Fahd University of Petroleum and Minerals, Saudi Arabia); Rifaqat Hussain (KFUPM, Saudi Arabia); Mohammad S. Sharawi (King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia)

In this paper, a frequency reconfigurable multiple-input-multiple-output (MIMO) slot antenna is presented. The proposed design is low profile and compact with wide tunability range, covering several well-known frequency bands from 1800 MHz to 2450 MHz. The frequency reconfigurability is achieved by loading the annular slot with varactor diodes. The antenna system is also analyzed for MIMO performance metrics. Moreover, the effect of circular slot antenna on the chassis modes is also investigated using the theory of characteristic modes (TCM). The physical principle behind frequency reconfigurability is also investigated using TCM analysis. An interesting finding is observed using varactor diodes for frequency reconfigurability, that is the reactive impedance loading does not alter the modal significance (MS) plots but only aid in the input impedance matching at different frequency bands.

09:20 ***Characteristic Mode Analysis of Dielectric Resonator Antennas Using VEP and Interpolation***

Qi Wu (Beihang University, P.R. China)

Characteristic mode analysis (CMA) provides useful insights for the design of dielectric resonator antennas (DRAs). In this paper, an interpolation method is proposed to reduce the computational burdens of volume equivalence principle (VEP) based CMA. The CMA is performed at several discrete frequencies, and the eigencurrents and eigenvalues at intermediate frequencies are obtained using efficient polynomial interpolation. Several examples such as rectangular, hollow, and inhomogeneous DRAs are computed and compared with verified results.

09:40 ***Modal Decomposition Theory for Arrays of Dipoles***

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

Various modal decompositions are performed on an array of dipoles backed by electric ground plane. The theory is based on analytically prescribed current on dipoles so the decomposition returns directly excitation coefficients of an array with respect to given quantity.

10:00 ***UWB Differentially-fed Circular Monopole Antenna with Stable Radiation Pattern***

Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Marko Sonkki (University of Oulu, Finland); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain); Erkki T. Salonen (University of Oulu, Finland)

A small UWB circular monopole antenna with a differential feed is presented in this paper, as a solution to increase the stability of the radiation pattern of a single-fed circular monopole antenna. A detailed characteristic modes analysis is presented in order to support the selection of the feeding mechanism. Simulated active-S parameter is shown for the proposed antenna, showing a good matching for the UWB frequency range. Normalized surface current distributions are presented, and 3D radiation patterns are compared to a reference monopole. The antenna structure shows more stable and omnidirectional radiation patterns over the studied frequency range compared to a same sized single-fed reference monopole.

10:20 Coffee Break

10:50 ***Characteristic Modes of Slotted Planar Antennas***

Nora Mohamed Mohamed-Hicho (Universidad Politécnica de Valencia, Spain); Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Juan Ciafardini and Jose Bava (Universidad Nacional de La Plata, Argentina); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

In this paper, a modal analysis of a slot inserted in a finite ground plane is presented, giving physical understanding of its radiation behavior and the interaction effects between the slot and the plane. The Theory of Characteristic Modes (TCM) reveals that for the case of slotted planar antennas the modes of the slot do not appear as independent modes. This paper also shows that the slot resonance fixes the upper frequency of the excited modes in the combined structure formed by the slot and the finite plate. Moreover, the modal analysis demonstrates that the radiation pattern stability and the radiation bandwidth of the slot antenna are directly related with the size of the finite ground plane. The conclusions reached with the application of TCM can be employed to optimize the geometry and the size of the finite plate in order to prevent the excitation of non-desired modes.

11:10 ***EFIE Singularity Treatments and Their Effects on Characteristic Mode Dynamic Range***

Kurt Schab, Binbin Yang and Jacob Adams (North Carolina State University, USA)

The limited eigenvalue dynamic range calculated from a characteristic mode solution is studied. Two methods of handling singular terms in the electric field integral equation matrix filling process are reviewed. Characteristic mode solutions using each singular treatment are compared with modal solutions obtained from a commercial solver. Results show that small alterations to the handling of singular terms in the matrix fill stage can lead to large gains in spectral depth. These gains outpace improvements obtained by increasing total mesh density.

11:30 ***Analysis and Design of Metamaterial Structures Using the Theory of Characteristic Modes***

M. Hassanein Rabah (IFSTTAR & University Lille 1 Nord de France, France); Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France)

Metamaterial inspired concept is a very promising technique to miniaturise antennas suffering from their small electrical sizes while keeping a good radiation efficiency. In this paper, the theory of characteristic modes is used to perform a study of the powers and Q factors of metamaterial inspired antennas, such as the common 2D electric based monopole antenna with a meander line [1]. The aim of this work is to initiate to a new methodology to be used by antenna designers to address the problem of associating metamaterial inclusions to electrically small antennas in order to enhance their performances. It will be able to find the adequate inclusion in order to match an arbitrary shaped antenna in its electrically small regime and keep high overall efficiency. This will require the solving of the eigenvalue problem with further post-processing of the quantities provided by the theory of characteristic modes.

11:50 ***Application of Characteristic Modes for the Analysis of Scattering from Dielectric Coated Conducting Bodies***

Liwen Guo and Yikai Chen (University of Electronic Science and Technology of China, P.R. China); Shiwen Yang (University of Electronic Science and Technology of China (UESTC), P.R. China)

As we all know, the merits of characteristic mode (CM) theory in antenna designs and optimizations have been well recognized in our EM community. In this paper, the scattering analysis for dielectric coated conducting bodies will be reconsidered using a novel CM formulation we developed very recently. The contribution of each mode to the total scattering response are clearly demonstrated. It offers deep physical insight into the scattering mechanism and valuable information on how to control and adjust scattering patterns. Numerical results are presented to demonstrate the accuracy of the proposed CM formulation in scattering analysis.

12:10 ***Excitation of Optimal and Suboptimal Currents***

Miloslav Capek and Lukas Jelinek (Czech Technical University in Prague, Czech Republic); Petr Kadlec (Brno University of Technology, Czech Republic); Martin Strambach (Czech Technical University in Prague, Czech Republic)

The potential ways how to excite optimal currents are discussed in this paper. It is be shown that realistic feeding is not compatible with optimal current distributions and therefore proper shape modifications are needed, changing thus, however, the original optimal currents. A set of deterministic algorithms to synthesize feeding network or the radiators geometry will be summarized, and novel procedure to get suboptimal shapes will be presented. Results will be compared with state-of-the-art multi-objective algorithm. The paper is concluded with an observation that

present understanding of geometry optimization needs to be extended alongside with deeper understanding of influence of the radiator's shape on its physical behavior.

Thursday, March 23, 08:40 - 10:20

C_A02 Small and Compact Antennas

TOP

Cellular Communications / Regular Session / Antennas
Oral Sessions: Room 342A
Chairs: Jaume Anguera (Fractus, Spain), Mats Gustafsson (Lund University, Sweden)

08:40 ***On the Use of Wheeler Cap for MIMO Antennas***
Florian Reher (RWTH Aachen University, Institute of High Frequency Technology); Adam Narbudowicz and Max James Ammann (Dublin Institute of Technology, Ireland); Dirk Heberling (RWTH Aachen University, Germany)
A new equivalent circuit based Wheeler Cap method to calculate MIMO efficiency is introduced. The method works without the necessity for interpolation by avoiding concur of resonating and cavity modes. The method is tested with a set of three differently correlated MIMO antennas. Results are compared with the recently proposed quality factor method for MIMO antennas and efficiency data from spherical near field measurements.

09:00 ***Antenna Array Construction on a Mobile Terminal Chassis at 3.5 GHz for LTE Advanced***
Igor Syrytsin, Shuai Zhang and Gert Pedersen (Aalborg University, Denmark)
This paper proposes a method of constructing an antenna array on the typical ground plane of the modern mobile terminal. An IFA and a slot in a metal frame antenna elements have been used to illustrate the proposed method. The radiation pattern of the element is recorded at the chosen number of the discrete locations on the ground plane. Antenna elements at the positions, where the boresight is similar and the maximum gain is high are combined into an array. The performance is verified by comparing performance of the one antenna element to the performance of the constructed arrays. The proposed method works both in free space and in data mode for two types of antenna elements. The method shown that a maximum gain of the constructed array is 1 to 2.5 dB higher then the gain of a single element both in free space and in data mode.

09:20 ***Analysis and Design of a Four-Element Superdirective Compact Dipole Antenna Array***
Antonio Clemente (CEA-LETI Minatec, France); Cyril Jouanlanne (CEA, France); Christophe Delaveaud (CEA-LETI, France)
This paper presents the design, optimization and experimental characterization of a four-element superdirective array based on a folded meandered dipole element. The proposed array is composed of an active and three parasitic elements. The optimal impedance loads associated to each parasitic elements have been extracted using an ad-hoc synthesis method based on spherical wave expansion. In order to optimize the realized gain, a printed balun has been integrated on the active element. A maximum directivity of 10.0 dBi and a realized gain equal to 0.82 dBi have been respectively demonstrated at 861 MHz when the element spacing is fixed to 0.15lambda.

09:40 ***A 4 x 4 MIMO Multiband Antenna System with Non-Resonant Elements for Smartphone Platforms***
Jaume Anguera, Aurora Andújar and Rosa Mateos (Fractus, Spain); Sungtek Kahng (University of Incheon, Korea)
MIMO technology allows high-data rates in wireless devices. A 4 x 4 MIMO multiband antenna system is proposed using small non-resonant elements placed each one at different corners of a smartphone platform. Electromagnetic analysis as well as an experimental demonstrator show that a compact solution using four non-resonant elements of 10 mm x 3.2 mm x 3.2 mm operating at 824MHz-960MHz and 1710MHz-2400MHz can achieve multiplexing efficiencies of 36% and 53% at each frequency region, respectively.

10:00 ***Miniaturization of Dipole Antenna Based on Complex Meta-Material Substrate and Its Application to MIMO System***
Yun Sik Kim (Korea Advanced Institute of Science and Technology (KAIST), Korea); Dong-Ho Cho (Korea Advanced Institute of Science and Technology, Korea)
This paper introduces a miniaturized antenna structure with a complex substrate, which is composed with CER-10 and meta-material. This complex substrate influences to the impedance value of antenna system, then this can make the antenna size reduction. The proposed antenna structure reduces the conventional antenna size by 66.7 %. The proposed antenna provides 130 MHz bandwidth with the center frequency 1.8 GHz, and the total radiation efficiency of proposed antenna structure is 48.37 %. The S-parameter characteristic variation for some parameters, such as the dipole length, distance between 2 dipoles and the height of meta-material has been analyzed. For the detailed analysis, the equivalent circuit model has been proposed, and has been verified by checking the S-parameter variation according to the variation of important parameters. For the effect of miniaturization on the MIMO environment, the channel capacity comparison in terms of the integration and mutual coupling have been analyzed.

Thursday, March 23, 08:40 - 12:30

CS16 European Academic and Industrial Advances in Microwave Medical Technologies (COST TD1301 MiMed)

TOP

Biomedical / Convened Session / Propagation
Oral Sessions: Room 342B
Chairs: Lorenzo Crocco (CNR - National Research Council of Italy, Italy), Panagiotis Kosmas (King's College London, United Kingdom)

08:40 ***Overview of Microwave Medical Applications in Europe Since the Beginning of the COST Action TD1301 - MiMed***

Raquel C. Conceição (Instituto de Biofísica e Engenharia Biomédica, Faculdade de Ciências, Universidade de Lisboa & Institute of Biomedical Engineering, University of Oxford, Portugal); Dario B. Rodrigues (Thomas Jefferson University, USA); Bárbara L. Oliveira (National University of Ireland, Galway, Ireland); Maria Koutsoupidou (National Technical University of Athens, Greece); Giuseppe Ruvio (Bioinnovate, National University of Ireland Galway, Ireland)

In the last twenty years, Microwave Imaging (MWI) has emerged as one of the most promising novel medical imaging modalities. With European researchers being at the forefront of MWI development of medical applications, the creation in 2013 of the Action network "MiMed" (MIcrowave MEDical) in the framework of the European COoperation in Science and Technology (COST) was welcomed with vivid enthusiasm. MiMed has polarised mostly independent research efforts into the design of several MWI devices. Such a reserve of knowledge and numerous initiatives carried by MiMed have constituted a unique opportunity for researchers to leverage existing experience and expertise to streamline the transition from simulation/phantom testing to full clinical trials and clinical adoption of MWI devices. Moreover, collaboration among participants has provided the support to overcome common challenges and bring MWI from "research bench to patient bedside", boosting the European Research Area and its excellence in a worldwide context.

09:00 ***Reference Phantoms for Microwave Imaging***

Nadine Joachimowicz (Group of Electrical Engineering - Paris / CentraleSupelec, France); Bernard Duchêne (Laboratoire des Signaux et Systèmes/Supèlec/CNRS, France); Christophe Conessa (GeePs/CentraleSupélec/CNRS, France); Olivier Meyer (Group of Electrical Engineering - Paris / CentraleSupelec, France)

Microwave imaging offers an alternative modality for breast cancer screening and for the diagnosis of cerebrovascular accidents. Before clinical application, the performances of microwave imaging systems have to be assessed on anatomically detailed anthropomorphic phantoms. This paper presents advances in the development of breast and head phantoms based upon 3D-printed structures filled up with liquid solutions that mimic the biological tissues in terms of complex permittivity in a broad microwave frequency band.

09:20 ***Quality Control of Carbon-Rubber Tissue Phantoms: Comparative MRI, CT, X-ray and UWB Microwave Measurements***

Jochen Moll and Dennis Wörtge (Goethe University Frankfurt am Main, Germany); Viktor Krozer (Goethe University of Frankfurt am Main, Germany); Adam Santorelli and Milica Popović (McGill University, Canada); Babak Bazrafshan, Frank Hübner and Thomas Vogl (Goethe University Hospital Frankfurt am Main, Germany); Natalia Nikolova (McMaster University, Canada)

Carbon-rubber phantoms have recently been introduced as tissue-mimicking materials for microwave biomedical applications. In contrast to other phantom materials, carbon-rubber materials allow easy construction of heterogeneous phantoms with time-stable dielectric properties. However, the fabrication of large solid phantoms may pose a challenge. This paper investigates a large dielectric carbon-rubber phantom with four inclusions with an average dielectric contrast of only 10%. In order to comparatively evaluate the quality of the phantom material, MRI, CT, X-ray and UWB microwave measurements have been performed. The measurement results of all modalities are here presented and discussed.

09:40 ***Experimental Assessment of Qualitative Microwave Imaging Using a 3-D Realistic Breast Phantom***

Jorge Tobon Vasquez, Francesca Vipiana, Mario Roberto Casu, Marco Vacca and Imran Sarwar (Politecnico di Torino, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Nadine Joachimowicz (Group of Electrical Engineering - Paris / CentraleSupelec, France); Bernard Duchêne (Laboratoire des Signaux et Systèmes/Supèlec/CNRS, France)

In this work we present an experimental study of qualitative microwave imaging algorithms for breast cancer detection. All the experiments are carried out with a 3-D printed realistic breast phantom filled with designed tissue mimicking liquids. In the following, the first experimental results using the Truncated Singular Value Decomposition (TSVD) scheme and the Linear Sampling Method (LSM) reconstructions are reported.

10:00 ***Development of a Portable Setup Suitable for in Vivo Measurement of the Dielectric Properties of Biological Tissues***

Laura Farina (Department of Information Engineering, Electronics and Telecommunications, Sapienza University of Rome, Rome, Italy); Giuseppe Ruvio (BioInnovate Ireland, Block E, National University of Ireland Galway – NUIG, Galway, Ireland); Rosanna Pinto (Division of Health Protection Technologies, ENEA, Rome, Italy); Luca Vannucci (Institute of Microbiology,

Czech Academy of Sciences, v. v. i., Prague, Czech Republic); Marta Cavagnaro (Department of Information Engineering, Electronics and Telecommunications, Sapienza University of Rome, Rome, Italy); Vanni Lopresto (Division of Health Protection Technologies, ENEA, Rome, Italy)

In the present paper, a preliminary study for the development of a portable setup suitable for in vivo measurements of tissue dielectric properties is presented. The setup consists of a hand-held spectrum analyzer, equipped with a tracking generator to operate as a vector network analyzer, and an in-house software for the post-processing of measured parameters. The proposed setup was optimized to operate in a broad frequency band (from 500 MHz to 3 GHz), minimizing the measurement uncertainty. The reliability of the setup was assessed through a comparative study with a commercial system, measuring the dielectric properties of reference liquids and ex vivo biological tissue samples.

10:20 Coffee Break

10:50 *Investigation of Antenna Array Configurations for Dispersive Breast Models*

Lena Kranold, Pragyan Hazarika and Milica Popović (McGill University, Canada)

Multiple numerical and experimental studies on multistatic radar systems for breast screening have been reported. In this context, this work investigates several antenna-array configurations tested on a dispersive numerical breast model. Each element is an ultrawideband rectangular flexible single-polarization antenna. The simulated collected signals are treated with a Delay-Multiply-and-Sum algorithm to assess the detection accuracy and the image quality for each array arrangement. Advantages and drawbacks of four antenna layouts are presented and results discussed in the attempt to identify a favorable array form for our specific antenna design.

11:10 *Brain Stroke Monitoring Using Compressive Sensing and Higher Order Basis Functions*

Marija Nikolic (University of Belgrade, Serbia); Rosa Scapaticci (CNR-National Research Council of Italy, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy)

We consider the utilization of higher-order basis functions, in the sparse processing framework, for brain stroke monitoring. Instead of retrieving the permittivity of the whole brain, the goal is estimate the variation of the electromagnetic parameters of the brain between two measurements. We assume that the differences in the measured electromagnetic field indicate the stroke evolution. Using average head model and different noise levels, we show that the method yields accurate results even for low signal-to-noise ratios (SNR) and limited prior knowledge of the brain tissue parameters

11:30 *Microwave Vision: From RF Safety to Medical Imaging*

Angie Fasoula (Microwave Vision Group, France); Shoaib Anwar (Microwave Vision Group, Satimo Industries, France); Yann Toutain (Microwave Vision, France); Luc Duchesne (SATIMO main Office, France)

This article gives an overview of the activities of the company Microwave Vision, formerly Satimo, oriented to health-related applications. The existing products in terms of Specific Absorption Rate (SAR) measurement and RF safety are described in detail. The progress of the development of a new imaging modality for breast pathology detection using microwaves is shortly reported.

11:50 *Blind Focusing of the Electric Field in Microwave Hyperthermia Exploiting Magnetic Nanoparticles*

Gennaro Bellizzi (University of Naples Federico II, Italy); Ovidio Mario Bucci (University of Naples, Italy)

This paper presents a novel approach to microwave hyperthermia exploiting magnetic nanoparticles as focusing agents, and reports the results of a 2D numerical study aimed at preliminarily assessing its effectiveness. The approach exploits magnetic nanoparticles, locally supplied to the tumor, to induce, through an external polarizing magnetic field, a detectable variation of its magnetic contrast. This variation is exploited to determine the excitations of the antenna array focusing the electromagnetic energy on the tumor. The advantage is that the synthesis of the excitations does not require any information neither on the geometry nor on the electromagnetic properties of the treated region, thus achieving totally blind field focusing. The magnetic nature of the magnetic nanoparticles contrast has required the development of an ad-hoc synthesis strategy, which, together with the use of magnetic nanoparticles, represents the novelty of the approach.

12:10 *MNP Enhanced Microwave Breast Cancer Imaging Based on Ultra-Wideband Pseudo-Noise Sensing*

Sebastian Ley (Technische Universität Ilmenau, Germany); Jürgen Sachs (Ilmenau University of Technology, Germany); Marko Helbig (Technische Universität Ilmenau, Germany)

Magnetic modulated nanoparticles are a promising approach to enhance microwave breast cancer detection and imaging. Assuming that functionalized magnetic nanoparticles are able to accumulate selectively within tumorous tissue, this approach can increase the diagnostic reliability. This contribution deals with detecting and imaging of magnetic nanoparticles by means of ultra wideband sensing. Magnetic nanoparticles are modulated by means of an external magnetic field and the resulting scattering changes of the magnetic nanoparticles are measured using M-sequence radar technology. Investigations are based on phantom measurements and the detection of the response caused by magnetic nanoparticles is realized by a differential measurement between ON- and OFF-state of the polarizing magnetic field. Results show a detectability of magnetic nanoparticles in a realistic measurement scenario. Based on this, 3D images for different amounts of magnetic nanoparticles are realized using a delay-and-sum beamforming algorithm.

High Data-rate Transfer / Convened Session / Antennas
Oral Sessions: Room 343
Chairs: Zhi Ning Chen (National University of Singapore, Singapore), Ronan Sauleau (University of Rennes 1, France)

08:40 ***High Gain V-Band Planar Array Antenna Using Half-Height Pin Gap Waveguide***
Parastoo Taghikhani (Amirkabir University of Technology, Iran); Jian Yang and Abbas Vosoogh (Chalmers University of Technology, Sweden)
With growing demand for mm-Wave applications, gap waveguide technology introduced many advantageous features compared to hollow waveguides or SIW. Till now several wideband, high-efficiency and highly directive planar gap waveguide antennas have been proposed. Recently, a new form of pins, the so called half-height pin, is proposed for realizing gap waveguide technology. In this paper, a wide-band, high gain, and high efficiency 8x8-element slot array antenna for 60 GHz band based on the new form of pins is introduced. The simulation shows a very good performance of the antenna, with 14% bandwidth of the 10 dB return loss, 26 dBi realized gain and close to 80% aperture efficiency. The antenna has less difficulty in manufacturing because of new pin form and therefore is suitable for the low cost mass production of mm-Wave antennas.

09:00 ***Broadband CTS Antenna Array at E-band***
Thomas Potelon (IETR - University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Laurent Le Coq (University of Rennes 1 & IETR, France); Terry Bateman and Jim Francey (Optiprint AG, Switzerland); Delphine Lelaidier and Eric Seguenot (Orange Labs, France); Frédéric Devillers (Orange Labs-CREMANT, France); Ronan Sauleau (University of Rennes 1, France)
A compact 32-slot continuous transverse stub (CTS) antenna array operating at E-band is proposed here. It is excited by a hollow parallel plate waveguide (PPW) corporate feed network to insure a broad band operation. A parabolic pillbox coupler is used to create the requested current line exciting for the PPW beamformer. The pillbox coupler is fed by a substrate integrated waveguide (SIW) horn located in the focal plane of the parabola. The most important features of the antenna building blocks are described in detail, and the numerical results demonstrate the excellent performance of the proposed antenna. A reflection coefficient lower than -19 dB and a gain larger than 31 dBi are obtained over a 19% fractional bandwidth spanning between 71 and 86 GHz. The proposed antenna architecture is an innovative solution for E-band backhauling applications for next generation 5G networks.

09:20 ***Dielectric-filled Waveguide Antenna Array for Millimeter-Wave Communications***
Henri Kähkönen (Aalto University, Finland); Vasilii Semkin (Aalto University School of Electrical Engineering, Finland); Juha Ala-Laurinaho (Aalto University, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)
In this work, the concept of dielectric-filled waveguide antenna array operating at 71-76 GHz is studied. The developed prototype consists of air-filled to dielectric-filled waveguide transition, dielectric filled power divider, and four dielectric radiating elements. The idea behind using dielectric-filled components is to minimize feeding waveguide structure dimensions in order to have spacing of half a wavelength between the radiating elements. This can help to reduce the grating lobes and it can be possible to integrate phase shifters since there is enough space between the elements. Such antenna structure is a light-weight and low cost in manufacturing. The simulation results show that such antenna array has 11.4 dBi gain with 23.6 half power beamwidth.

09:40 ***Q-band High Gain Radome Integrated Lens Antenna for Compact Backhaul Terminal***
Romain Czarny and Mane-Si Laure Lee (Thales Research & Technology France, France); Brigitte Loiseaux (Thales Research & Technology, France); Michal Makowski (Orteh, France); Andrzej Siemion and Maciej Sypek (Orteh, Poland); Alain Le Fevre (Thales Communications & Security, France)
This paper describes the design, fabrication and characterization of a 42 GHz compact lens antenna integrated in a backhaul terminal radome. The proposed lens concept relies on the use of hybrid design that mixes a single refractive bulk zone and dielectric structured zones. This allows overcoming usual Fresnel lens efficiency limitations occurring in compact configurations. The antenna is composed of a small microstrip patch array feeder and of a radome integrated square lens. Radome was manufactured using an additive manufacturing technique. The fabricated antenna was fully characterized and exhibit characteristics suitable for point-to-point backhaul applications.

10:00 ***In-Antenna Power-Combining Methods***
Benjamin Goettel, Jochen Schäfer, Akanksha Bhutani and Heiko Gulan (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Karlsruhe Institute of Technology (KIT), Germany)
In this paper different possibilities for an in-antenna power-combining approach are investigated. The radiation is based on the principle of an integrated lens antenna (ILA), where the primary radiator consists of a slot antenna with two or more excitation elements. The output power of parallel amplifiers can be directly combined in the primary radiator itself without any additional combiner network. Regarding the antenna efficiency, the practical limit for the number of parallel branches is found out by simulations. Additionally, different power-splitter networks for achieving a linearly or circularly polarized radiation are presented and it is shown how the input impedance of the excitation elements changes with different number of feed-lines. Finally, primary radiators with different input impedances and polarization schemes are presented and verified by calibrated gain measurements in D-band and H-band frequencies.

10:20 Coffee Break

10:50 ***Gain Enhanced Millimetre-Wave Beam-Switching Rotman Lens Antenna Designs on***

LCP

Antti E. I. Lamminen, Jussi Säily and Mikko Kaunisto (VTT Technical Research Centre of Finland, Finland); Michal Pokorný (Brno University of Technology, Czech Republic); Jouko Aurinsalo (VTT Technical Research Centre of Finland, Finland); Zbynek Raida (Brno University of Technology, Czech Republic)

Compact and low-cost antenna arrays with beam-steering or beam-switching are needed for emerging millimeter-wave communication systems such as 5G and WLAN at the 60 GHz frequency band. The design, manufacturing and measurement results for a 60 GHz beam-switching Rotman lens integrated with a 4×8 patch antenna array are presented. Active versions with integrated amplifiers are also developed. The presented design can electrically switch between five different beam directions -23°, -12°, 0°, 12° and 23°. Antenna gains of 8 dBi and 26.5 dBi are measured at 60 GHz for passive and active beam-switching Rotman lens antennas.

11:10 ***V-Band Transceiver Modules with Integrated Antennas and Phased Arrays for mmWave Access in 5G Mobile Networks***

Loic Marnat, Laurent Dussopt and Vincent Puyal (CEA, LETI, Minatec, France); Alexandre Siligaris (Cea, Leti, Minatec, France); Fredeic Hameau (CEA Atomic Energy Commission, France); Aurelien Larie (CEA, LETI, Minatec, France); Cedric Dehos (CEA, France)

V-band integrated transceiver modules based on a multi-layer organic interposer technology are developed for user terminal and access point applications in future 5G mobile networks with the objective to have an efficient, scalable and cost-effective architecture. The main design constraints and issues are discussed. A 10×10-mm2 transceiver module, designed for user-terminal applications, with separate Rx and Tx antennas is presented and exhibits more than 8.6 dBi antenna gain over the 60 GHz band. A 18.8×18.5-mm2 module integrating a transceiver IC, 4 phase shifter ICs and 2×4 antenna elements enables higher gain levels and beam-steering in Rx and Tx modes. This module offers 17.6 dBi antenna gain at 61 GHz and can be used as a sub-array to reach 26.6 dBi in a multi-module phased-array architecture composed of 2×4 sub-arrays.

11:30 ***Generic Formulation for Transmit-Array Dual-Band Unit-Cell Design***

Sérgio Matos (Instituto de Telecomunicações, Portugal); Eduardo B. Lima (Instituto de Telecomunicações & Instituto Superior Técnico, 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)

For the implementation of high-gain dual-band transmit-arrays, adequate unit-cells have to be designed. The potential difficulty is related to the independent 360º phase wrapping needed at each band to compensate arbitrarily large equivalent path length phase compensation. This points to an intractable number of phase combinations at each band, leading to a possibly very large number of different unit-cells. A generic formulation is presented for the design of dual-band unit-cells that considerably reduces the search space leading to thinner and lighter configurations. An example, is presented for Ka-band with a configuration of dual-band unit-cells working simultaneously at 20 and 30 GHz. The unit-cells ensuring both the required phase values and a transmission coefficient amplitude better than -0.9 dB in both bands.

11:50 ***Multiple-Feed Integrated Lens Antenna with Continuous Scanning Range***

Alexey Artemenko (Radio Gigabit LLC); Andrey Mozharovskiy, Sergey Tikhonov and Alexander Myskov (Radio Gigabit LLC, Russia); Roman Maslennikov (Radio Gigabit LLC)

The paper presents a novel concept of the integrated lens antenna (ILA) that includes multiple feeds and provides continuous scanning without gain degradation in the given scanning sector. Each feed includes its own RF mixing stage and a radiating element mounted on the lens back focal surface. Continuous scanning is achieved by the power distribution over all the radiating elements that leads to a predictable displacement of the common phase center of the group of active elements relatively to the lens axis. The lens focuses the radiation in the particular direction defined by this phase center position. Low losses and continuous scanning range make this ILA concept perspective for practical implementation in different millimeter-wave applications like point-to-point radios and future 5G systems.

12:10 ***18-40GHz Low-profile Phased Array with Integrated MEMS Phase Shifters***

Anas Abumunshar and Niru Nahar (The Ohio State University, USA); Daniel Hyman (XCOM Wireless Inc., USA); Kubilay Sertel (The Ohio State University, USA)

We present a low profile, wideband beam-steering antenna for continuous coverage of the K- and Ka-bands (18-40GHz). The array is based on the tightly coupled dipole principle and micro-electro mechanical systems (MEMS) phase shifters are integrated into each element for real-time beam forming. This topology leads to significant reduction in the size, weight, complexity, and cost of the phased array. A proof-of-concept 8x8 array is simulated using Ansoft HFSS v15.0. Among the major design challenges addressed are the optimization of the feeding structure and the design of the tightly coupled array elements.

Thursday, March 23, 08:40 - 10:20

TOP

F_A06 Nano Antennas

Future Applications / Regular Session / Antennas

Oral Sessions: Room 351

Chairs: Wonbin Hong (Pohang University of Science and Technology (POSTECH), Korea), Juan M. Rius

(Universitat Politècnica de Catalunya, Spain)

08:40 ***On the Resonant Frequency of Pre-fractal Plasmonic Antennas***

Juan M. Rius (Universitat Politècnica de Catalunya, Spain); Hector Lopez-Menchon (Universitat Politecnica de Catalunya (BarcelonaTECH), Spain); Alexander Heldring (Polytechnical University of Catalunya, Spain); Eduard Ubeda (Universitat Politècnica de Catalunya (UPC), Spain)

Pre-fractal wire antennas show a decreasing resonant frequency for increasing iteration number due to the longer wire length. However, the resonant frequency reduction stagnates after a few iterations. This paper gives an explanation for this behavior, that we call the shortcut effect, based on the signal taking shortcuts between wire corners. This hypothesis is verified by computer simulation in the time domain and it is shown that it is almost not present in the plasmonic regime at optical frequencies: the high-localization of plasmonic modes mitigates the shortcut signal, so that plasmonic antennas show a much better reduction of the resonant frequency for a higher fractal iteration count that the microwave frequency ones.

09:00 ***Terahertz Wireless Data Transmission with Frequency and Polarization Division Multiplexing Using Resonant-Tunneling-Diode Oscillators***

Naoto Oshima, Kazuhide Hashimoto, Safumi Suzuki and Masahiro Asada (Tokyo Institute of Technology, Japan)

A resonant-tunneling-diode terahertz (THz) oscillator chip for frequency- and polarization-division multiplexing was fabricated. Wireless data transmissions using 2-channel frequency-division multiplexing with ranges of 500 and 800 GHz and polarization-division multiplexing at 500 GHz range were demonstrated. Transmissions up to a data rate of 28 Gbps for each channel under an error-correctable error rate were achieved in both the multiplexing technologies.

09:20 ***Invisible Antennas Using Mesoscale Conductive Polymer Wires Embedded Within OLED Displays***

Wonbin Hong (Pohang University of Science and Technology (POSTECH), Korea); Seungtae Ko, Yoon Geon Kim and Sangho Lim (Samsung Electronics, Korea)

An efficient, optically invisible antenna applied on the touch OLED display panel is presented and demonstrated for the first time in literature. A transverse magnetic (TM01) patch antenna is devised at 2.45 GHz on the display panel surface of a real-life smartwatch device and its radiation properties, optical visibility and touch functions are investigated.

09:40 ***Near-field Microwave CPW Antenna for Scanning Microscopy***

Sofiane Ben Mbarek (Innov'Com Laboratory, SUPCOM, University of Carthage, Tunisia); Fethi Choubani (Innov'Com Laboratory, SUPCOM, University of Carthage, Tunisia); Bernard Cretin (Université de Franche-Comté, CNRS, ENSMM, UTBM, France)

In this work, we present a non-conventional coplanar microwave antenna for near-field applications. This electrical probe is a combination of coplanar line and the point effect. We achieved prototypes of micro-antennas using the clean room techniques. To overcome the oxidation problem, we chose gold as metal structure. We used an oxidized silicon substrate in order to reduce losses in the silicon. Performed measurements and simulations have shown that the antenna is mainly sensitive to the longitudinal electric field. The estimated sensitivity is 30 V/(V/m).

10:00 ***Plasmonic Photovoltaics Using Nano Crescent Antennas***

Marina Medhat, Yasser El-Batawy and Alaa Abdelmageed (Cairo University, Egypt); Ezzeldin Soliman (The American University in Cairo, Egypt)

In this paper a novel nanoparticle structure has been presented to be used in plasmonic photovoltaic to enhance its efficiency. The proposed structure is expected to make good enhancement of light absorption inside the active layer of the photovoltaics (PV) in the visible and near infrared range of frequencies (200-900 THz). In this work, the proposed Nano-antenna is in a shape of crescent with a gap on its side, that is embedded inside the photovoltaic cell resulting in a highly confined near-field around the nanoparticle and with the semiconductor forming the PV. The extinction cross-section of the proposed nanoparticle in vacuum has been calculated versus the wavelength. And, the modes of the fields are studied. The effect of embedding this crescent nanoparticle in a silicon photovoltaic is investigated by comparing its absorption with the conventional disk nanoparticle. The proposed structure enhances the light absorption improving the efficiency of the PV.

Thursday, March 23, 08:40 - 12:30

TOP

CS15 Emerging Strategies for the Synthesis of Innovative Array-Antenna Architectures

Radars / Convened Session / Antennas

Oral Sessions: Room 352A

Chairs: Andrea Francesco Morabito (University Mediterranea of Reggio Calabria, Italy), Paolo Rocca (University of Trento, Italy)

08:40 ***Dual-polarization Beam Forming Networks Based on High Order Directional Couplers***

Michela Longhi (University of Rome "Tor Vergata", Italy); Jaione Galdeano (European Space Agency, The Netherlands); Antonio Morini and Marco Baldelli (Università Politecnica delle

Marche, Italy); Piero Angeletti and Giovanni Toso (European Space Agency, The Netherlands); Giuseppe Venanzoni (Università Politecnica delle Marche, Italy)

A Ka-band dual-polarization 3 dB directional coupler is designed for Beam Forming Network applications. The proposed solution is particularly suited for compact Nolen networks. Nolen architecture is attractive because it is planar and lossless. Two parallel square waveguides are coupled through an array of apertures, designed to get the desired coupling and high isolation between the two orthogonal polarizations.

09:00 ***Multi-Technology Wireless Coverage Based on a Leaky-Wave Reconfigurable Antenna***

R. dos Santos (National Institute of Telecommunications (INATEL), Brazil); Andre Marques Muniz (National Institute of Telecommunications & National Institute of Telecommunications, Brazil); Matheus Borsato and Tiago Brandão (Inatel, Brazil); Tercio Rodovalho (Inatel - National Institute of Telecommunications, Brazil); Arismar Cerqueira S. Jr. (INATEL, Brazil)

We propose the concept and report the implementation of multi-technology wireless network based on the use of a leaky-wave reconfigurable antenna, which operates from 1.7 to 2.7 GHz. The proposed printed antenna provides a frequency-dependent reconfigurable radiation pattern. Numerical analyses and experimental results have been shown in excellent aggrement and demonstrate a fractional bandwidth of 45% and gain maximum of 9.2 dBi.

09:20 ***Shared Aperture Metasurface Antennas for Multibeam Patterns***

David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Gabriele Minatti and Enrica Martini (University of Siena, Italy); Goutam Chattopadhyay (JPL, USA); Stefano Maci (University of Siena, Italy)

This paper describes various possibilities for designing multibeam antennas using a single metasurface (MTS) aperture. Both single-source and multi-source feeding schemes are considered. For the single-source case, two approaches are investigated: i) division of the aperture in several angular sectors (one per beam) and ii) superposition of the individual modulations required to obtain the beams in the desired directions. A configuration based on a multi-source feeding scheme is also tailored by a superposition of modulation patterns. Numerical results based on the Method of Moments are presented for validation.

09:40 ***Synthesis of Maximally-Sparse Square or Rectangular Arrays Through Compressive Sensing***

Andrea Francesco Morabito (University Mediterranea of Reggio Calabria, Italy)

The synthesis of square or rectangular array antennas able to generate mask-constrained shaped beams by exploiting the minimum number of radiating elements is addressed and solved. The approach represents a powerful extension of a design procedure available for the one-dimensional case and able to outperform most of previous synthesis techniques. By exploiting at best the multiplicity of equivalent solutions available for the generation of an unique shaped-beam power pattern, the theory of Compressive Sensing, and a smart formulation in terms of a Convex Programming problem, the proposed design technique results extremely fast and effective.

10:00 ***The Synthesis of Array Antennas Using the Element-Level Pattern Diversity (ELPD) Technique***

Di Hua (Nanjing University of Science and Technology, P.R. China); Wen Wu and Da-Gang Fang (Nanjing University of Science & Technology, P.R. China)

From the viewpoint of diversity, this paper presents the applications of element-level pattern diversity (ELPD) technique in the synthesis of array antennas. The application examples include the linear array antennas, the concentric loop array antenna, conformal array antenna and the time-modulated array antenna. With one more degree of freedom in the synthesis, this technique exhibits many advantages. The limitations of this technique are also discussed. In addition to the simulations, the verification of this technique is given through a practical linear array antenna where the full wave analysis has been involved in the design.

10:20 Coffee Break

10:50 ***Low Sidelobe Synthesis of Dipole Arrays by Element Orientation Selection Using Binary Coded Genetic Algorithm***

Ming Li and Yanhui Liu (Xiamen University, P.R. China); Shu-Lin Chen, Peiyuan Qin and Y. Jay Guo (University of Technology, Sydney, Australia)

Selecting appropriate element orientations can significantly reduce the sidelobe level of the antenna array. In this paper, a binary coded genetic algorithm (BCGA) which selects the element orientations from specified discrete angles, is proposed to reduce the sidelobe level (SLL) of the array. Compared to the conventional GA, the BCGA is much faster in this application. Synthesis results show the effectiveness and efficiency of the proposed method.

11:10 ***Time-Delay Compensation in Array Lens Antennas***

Payam Nayeri and Randy L. Haupt (Colorado School of Mines, USA)

A phased array lens has limited bandwidth due to the phase shifters that collimate and scan the beam. A wideband signal requires time delay units in place of phase shifters. This paper investigates the feasibility of implementing time-delay units in array lens antennas. Time-delay compensation mechanisms for array lens antennas are outlined and investigations are carried to determine the required time-delay for these configurations. We show that time-delay array lens antennas are a practical solution for modern communication and radar systems.

11:30 ***Unconventional Techniques for the Synthesis of Modern Antenna Arrays***

Andrea Massa (University of Trento, Italy); Nicola Anselmi (ELEDIA Research Center, Italy); Giorgio Gottardi (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Lorenzo Poli and Paolo Rocca (University of Trento, Italy); Marco Salucci (ELEDIA Research Center, Italy); Lorenza Tenuti (ELEDIA

Research Center, University of Trento, Italy)
In this work, the synthesis of clustered antenna array architectures is addressed. The sub-arraying problem is formulated as a tiling one, and solved considering tiles of rectangular shape (domino). An optimization strategy is proposed to deals with medium/large array apertures, obtaining tiling configurations that are optimal in terms of aperture efficiency and sidelobe level (SLL). A simple example shows the effectiveness of the proposed approach for both square and arbitrary shaped array layouts.

11:50 ***Compensation Method for Distorted Planar Array Antennas Based on Structural-Electromagnetic Coupling and FFT***

Yan Wang and Congsi Wang (Xidian University, P.R. China); Baofu Tang and Jianfeng Zhong (Nanjing Research Institute of Electronics Technology, P.R. China); Jinzhu Zhou and Wei Wang (Xidian University, P.R. China)

Complex operating environment could introduce serious degradation to the electromagnetic property of active phased array antenna. The effective compensation techniques become the key for antenna to perform in reliable service condition. Therefore, a method combined coupled structural-electromagnetic modal with two-dimensional fast Fourier transform for compensation is presented. A calculation modal of the excitation current compensation for planar array is established accordingly. The adjustment quantities of excitation amplitude and phase can be quickly obtained corresponding to the position error of the element, which could be implemented to recover a high quality pattern from a distorted antenna. Lastly, an X-band space-based active phased array antenna is illustrated to compensate its property under the impact of both space environment and heat power from the electric devices.

12:10 ***Nearfield-based Array Design for a Realistic On-the-Move Personnel Inspection System***

Borja Gonzalez-Valdes and Yolanda Rodriguez-Vaqueiro (University of Vigo, Spain); Yuri Álvarez and Fernando Las-Heras (Universidad de Oviedo, Spain); Antonio Pino (University of Vigo, Spain)

Recently, the architecture of a novel imaging system able to create real time radar images for personnel security screening was presented. The imaging is performed as the person being screened continuously moves across a corridor populated with transmitters and receivers, and taking advantage of the person's movement to increase the number of observation angles. As part of a preliminary study to build a prototype of the system, this works presents the design of a sparse array system able to perform multistatic imaging. Optimal operation frequency, array size, and number of elements are discussed. Representative simulation results showing the feasibility of the proposed configuration are presented. The obtained architecture allows for excellent imaging capabilities with a reduced number of transceivers.

Thursday, March 23, 08:40 - 10:20

L_M02 Near-Field Measurements

TOP

Localization & Connected Objects / Regular Session / Measurements
Oral Sessions: Room 352B
Chairs: Ioan E. Lager (Delft University of Technology, The Netherlands), Francesca Mioc (Consultant, Switzerland)

08:40 ***A Near-Field Setup with Independent Amplitude and Phase Control of the Stimuli for Phased Antenna Testing***

Carmine De Martino, Marco Spirito and Ioan E. Lager (Delft University of Technology, The Netherlands); Massimiliano Simeoni (European Space Agency, The Netherlands)

This contribution discusses a near-field antenna setup capable of delivering multiple input signals with a controllable (i.e., user defined) amplitude and phase relations to an antenna under test, operating in the X-band. The setup is based on a Cartesian modulation (phase and quadrature signals) of phase coherent signals, achieved employing broadband passive IQ-mixers controlled via high-resolution digital-to-analogue converters (DACs). A dedicated calibration procedure allows achieving independent phase and amplitude control on the different signal paths to compensate for loss and delay mismatches among the different channels. The capability to align the relative phases of the various path with respect to one enables the direct testing of phased antenna arrays. The system calibration is elaborately described. The proposed Cartesian modulation is demonstrated by studying a complex antenna array, with a subset of its elements being controlled independently and phase delayed for actively controlling the far-field radiation pattern.

09:00 ***Application of the Translated-SWE Algorithm to Echo Reduction of Spherical Near-Field Measurements with Undersampling***

Francesco Saccardi and Lars Foged (Microwave Vision Italy, Italy); Francesca Mioc (Consultant, Switzerland); Per Iversen (Orbit/FR, USA)

In spherical Near Field (NF) measurements post-processing techniques based on spatial filtering have been presented as promising tools for the mitigation of echoes or stray signals deriving from the surrounding environment. The spatial filtering is very efficient in measurement scenarios with a stationary Antenna Under Test (AUT). Whenever the AUT is rotating, in order to increase the effectiveness of the echo reduction, the antenna needs to be displaced outside the center of rotation. Unfortunately, the measurement of the AUT in an offset configuration requires the acquisition of a number of samples higher respect to the onset configuration. An innovative spherical NF/FF transformation algorithm for offset measurements based on a Translated Spherical Wave

Expansion (TSWE) has been recently proposed. In this paper, we investigate by experiment the echo reduction properties of offset AUT measurements using TSWE.

09:20 ***Channel Models in the Near Field***

Akl Charaf (Telecom ParisTech, France); Georges Rodriguez-Guisantes (TELECOM ParisTech, France)

We present in this work the state of the art of near field communications (NFC) systems channel models. We proceed by proposing a new model and compare the performance with the most frequently used ones.

09:40 ***Three Dimensional Scanning System for Near-field Measurements***

Nimisha Sivaraman (IMEP & University Joseph Fourier, France); Kassem Jomaa (Grenoble University, France); Fabien Ndagijimana (University Joseph Fourier & IMEP-LAHC lab, France)

This paper presents a novel low cost three dimensional near-field scanning system consisting of a near field scanner and a three dimensional magnetic probe which reduces the large scanning time of the existing near field scanning systems and increases the spatial resolution. The paper focuses on the design, calibration and validation of a printed circuit three dimensional magnetic field probe. The proposed probe is printed on both sides an FR4 substrate of 3.2mm height. The total dimensions of the probe are 9x9x3.2mm3. The antenna factor of the designed probes is calculated using TEM cell for a frequency range from 10 MHz to 1 GHz. The proposed scanning system is validated by mapping the magnetic field above a wire over ground structure.

10:00 ***A Perturbation Based Method for Near-field 3-D Radar Imaging***

Yingzhi Kan, Jianxiong Zhou, Yongfeng Zhu, Liang Tang and Qiang Fu (National University of Defense Technology, P.R. China)

The paper proposes a fast and interpolation-free method for near-field 3-D radar imaging. The scattered data are measured on 2-D planar antenna array with wideband stepped frequency signal. The near-field 3-D imaging procedure is indeed a nonuniform summation problem. Different from the conventional interpolation fast Fourier transform (FFT) method, the proposed method regards the imaging procedure as a Fourier basis mismatch issue and utilizes perturbation technology to solve the problem. The nonuniform wavenumber grid is first approximated onto a newly reconstructed uniform grid by first-order Taylor expansion. Then the nonuniform spatial spectrum summation procedure can be efficiently implemented by two 3-D inverse FFTs to obtain 3-D image. Experiment demonstrates the effectiveness and efficiency of the proposed method.

Thursday, March 23, 08:40 - 12:30

CS39 Propagation Channels for Wide Sense Vehicle to X Communications

TOP

Cellular Communications / Convened Session / Propagation

Oral Sessions: Room 353

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

08:40 ***Wide Band Propagation in Train-to-Train Scenarios - Measurement Campaign and First Results***

Paul Unterhuber and Stephan Sand (German Aerospace Center (DLR), Germany); Mohammad Soliman (Deutsches Zentrum für Luft- und Raumfahrt, Germany); Benjamin Siebler (DLR-German Aerospace Center, Germany); Andreas Lehner (German Aerospace Center (DLR) & Intelligence on Wheels, Germany); Thomas Strang (German Aerospace Center (DLR) & University of Innsbruck, Intelligence on Wheels, Germany); Maurizio d'Atri and Fabrizio Tavano (Trenitalia S.p.A., Italy); Damini Gera (Technische Universität Ilmenau, Germany)

Within the next decades the railways will change to fully autonomous high speed trains. An increase in efficiency and safety and cost reductions would go hand in hand. Today's centralized railway management system and established regulations can not cope with trains driving within the absolute braking distance as it would be necessary for electronic coupling or platooning maneuvers. Hence, to ensure safety and reliability, new applications and changes in the train-control and -management are necessary. Such changes demand new reliable communication links between train-to-train (T2T) and future developments on train-to-ground (T2G). T2G will be covered by LTE-R which shall replace today's GSM-R. The decentralized T2T communication is hardly investigated and no technology has been selected. This publication focuses on the wide band propagation for T2T and describes a extensive channel sounding measurement campaign with two HSTs. First results of T2T communication at high speed conditions in different environments are presented.

09:00 ***Train-to-train Propagation At 450MHz***

Andreas Lehner (German Aerospace Center (DLR) & Intelligence on Wheels, Germany); Thomas Strang (German Aerospace Center (DLR) & University of Innsbruck, Intelligence on Wheels, Germany); Paul Unterhuber (German Aerospace Center (DLR), Germany)

Fundamental modernization of railway transportation is on the agenda of the Next Generation Train (NGT) project funded by the German Aerospace Center DLR and the Roll2Rail project within the Shift2Rail initiative. Reliable direct Train to Train (T2T) communication can significantly enhance train control and signaling towards semi or fully autonomous operation, in order to significantly increase the efficiency and safety. With Terrestrial Trunked Radio (TETRA) a communication standard is available with high potential for this use-case. It offers the ability of direct

communications between vehicles, i.e. ad-hoc communications over several kilometers. In this paper, we summarize the results of T2T measurements conducted at 450 MHz. We will characterize the propagation conditions and assess the link performance by analyzing transmissions in different scenarios and railway environments.

09:20 ***Analysis of the Millimeter Wave Channel Characteristics for Urban Micro-Cell Mobile Communication Scenario***

Pan Tang (Beijing University of Posts and Telecommunications, P.R. China); Lei Tian (Beijing University of Posts and Telecommunications & Wireless Technology Innovation Institute, P.R. China); Jianhua Zhang (Beijing University of Posts and Telecommunications, P.R. China)

To meet the rapid increasing demand of the high data rate communication, millimeter wave communication system has attracted considerable attention. In this paper, a millimeter wave wideband channel measurement with mobility in urban micro-cell mobile communication scenario at 28 GHz is presented for the purpose of capturing the channel characteristics. Based on the measured data, we analyze the path number, root mean square delay spread (rms DS) and mean excess delay. It is found that the distribution of the path number is well fitted by a Normal distribution while the distribution of the rms DS and mean excess delay is fitted well by a Lognormal distribution. The statistics of these parameters are also given and are compared with the results in other measurements. Besides, the effects of the distance on the path number are discussed. These analysis results can give insight into the design of the 5G wireless communication system.

09:40 ***Mobile Hotspot Network Enhancement System for High-Speed Railway Communication***

Junhyeong Kim, Hee Sang Chung and Sung Woo Choi (ETRI, Korea); Ilgyu Kim (ETRI of KOREA, Korea); Youngnam Han (KAIST, Korea)

The mobile hotspot network (MHN) system is a system for high-speed railway communications capable of providing a gigabit-per-second backhaul capacity employing millimeter-wave. This paper provides an overview of MHN enhancement (MHN-E) system that's been developed so far, and also addresses some of the major technical challenges that need to be overcome and discuss several viable technical solutions for further enhancements. One of the most important goals in the development of the MHN-E is to further increase wireless backhaul capacity and improve its reliability compared with the first version of the MHN system, which will meet the high-speed-related requirements set by ITU for IMT-2020 or 5G.

10:00 ***Ray-tracing Simulation and Analysis of Propagation for 3GPP High Speed Scenarios***

Danping He, Jingya Yang and Ke Guan (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); ZhuYan Zhao, Deshan Miao and Hao Guan (Nokia Siemens Networks, P.R. China)

In this paper, the propagation for 3GPP high speed train (HST) scenarios is studied both at 30 GHz and 3.5 GHz. Urban, cutting and viaduct scenarios are modeled and simulated by using 3GPP deployment configurations. The optimum direction of beam is suggested in order to achieve the best coverage. Propagation at 30 GHz and 3.5 GHz are compared in terms of received power and Doppler shift. The wideband path loss parameters are modeled, and suggestions are provided to guide high-data-rate HST communication system design.

10:20 Coffee Break

10:50 ***Propagation Measurements and Modelling Inside Trains at 900 MHz, 2.4 and 5.8GHz***

Lei Zhang (Universidad Politecnica de Madrid, Spain); Ana Gonzalez-Plaza (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain); Jean Fernandez (Universidad Politecnica de Madrid, Spain); Juan Moreno (Metro de Madrid S.A. & Universidad Politécnica de Madrid, Spain); Miguel Laso and Israel Arnedo (Public University of Navarre, Spain); Cesar Briso (Universidad Politecnica de Madrid & ETSIS Telecomunicacion, Spain)

The paper analyzes the possibility of providing reliable communications to the users of a high speed train (HST) using base stations (BTS) located in towers close to the track or in the station platforms. Measurements have been made on a real environment using test transmitters at 900, 2400 and 5700 Mhz, and making measurements inside a HST with external and internal antennas and a portable receiver. The results have shown a high shieling effect of the train at all frequencies and in both cases towers. With high towers the shieling effect of the train is 24dB and from the station platform is 17db. Higher frequencies have shown better behavior .

11:10 ***Influence of Railway Environment on Antenna Performances at Mm-Wave Frequencies***

Divitha Seetharamdoo (IFSTTAR, LEOST & Univ Lille Nord de France, France); Rafik Addaci (Insight SiP, France); vy Xuyen Pham and Christian Chagny (Metrolab, France); Kun Yang (IFSTTAR, France); Jean-Pierre Ghys (IFSTTAR, COSYS, LEOST, University Lille Nord de France, France); Marion Berbineau (IFSTTAR, COSYS & University Lille Nord de France, France)

In the context of a growing interest in the use of millimetre wave frequencies for railway applications, we propose to analyse the influence of this environment on antenna performances. The railway environment being quite harsh with the presence of lossy and conductive particles and elements, near-field effects can be detrimental to the efficiency of wireless links at these frequencies. This paper focuses on two specific conditions namely the presence of a layer of metallic dust and a thin water film on radiating elements. It is shown that the impact of these two parameters cannot be considered negligible. In an operational scenario, the antenna main lobe may be tilted backwards. For point-to-point communication systems, trackside antennas will be coated with a deposit of metallic dust. The deterioration of the radiation pattern and the reflection coefficient should be taken into account when forecasting radio propagation, establishing budget links and evaluating performance indicators.

11:30 ***Traffic Impact on Radio Wave Propagation at Millimeter-Wave Band in Tunnels for 5G Communications***

Andrej Hrovat (Jožef Stefan Institute, Slovenia); Ke Guan (Beijing Jiaotong University, P.R. China); Tomaz Javornik (Jozef Stefan Institute, Slovenia)

In this paper, the impact of truck convoys on radio wave propagation at the mm-wave frequency band in a two lane road tunnel is analyses by computer simulations. The analyzes reveal that the propagation of radio waves is not affected outside the convoy if a convoy occupies only one lane, while two convoys in both lanes cause serious drop of signal level behind the convoys. The signal level is decreased and delay spread is increased within the convoy, which suggests the usage of the vehicle to vehicle communication within a convoy. In addition, due to misalignment of transmitting and receive directional antennas a significant signal gap is occurred close to the base station. We suggest the usage of two antennas at the base station, one omnidirectional to cover proximity areas and the second one directional to cover distance areas along the tunnel.

11:50 ***Evaluation of Automotive MIMO Antennas for V2V Communication in Urban Intersection Scenarios***

Thomas Kopacz (RWTH Aachen University, Germany); Adam Narbudowicz (Dublin Institute of Technology, Ireland); Dirk Heberling (RWTH Aachen University, Germany); Max James Ammann (Dublin Institute of Technology, Ireland)

The usage of driving assistance systems that are based on V2X communication technologies as ITS-G5 are a promising technology to increase road safety as well as traffic efficiency. To allow for communication even in challenging propagation scenarios (such as busy urban intersection), we investigated a new concept for rooftop mounted beam-steerable vehicular antennas which is a 2-element monopole array (parallel and orthogonal to direction of travel) and a switchless reconfigurable antenna. It shows that the monopole array configurations give the best propagation results in any scenario and time step. However, the beams have to be steered dynamically to ensure the best possible communication.

12:10 ***Micro-Doppler Characteristics of Pedestrians and Bicycles for Automotive Radar Sensors at 77 GHz***

Domenic Belgiovane, Jr. (The Ohio State University & ElectroScience Laboratory, USA); Chi-Chih Chen (The Ohio State University, USA)

millimeter-wave automotive radar sensors will likely have the capability to utilize the micro-Doppler signatures for classifying different targets, especially pedestrians and bicyclists. This paper presents the study findings on micro-Doppler signatures associated with the movements of body and rotating wheels of pedestrian and bicyclist at 77 GHz. The pedestrian micro-Doppler signatures were studied analytically and experimentally. The micro-Doppler responses of bicycles were studied via experiments.

TOP

CS42 Satellite and Aerospace Antenna Measurements (AMTA/EurAAP)

Space / Convened Session / Measurements

Oral Sessions: Room 362/363

Chairs: Christian Hunscher (Airbus DS GmbH, Germany), Luca Salghetti Drioli (European Space Agency-ESTEC, The Netherlands)

08:40 ***Digitally Reconfigurable Approach to Compact Antenna Test Range Design***

Clive Parini (QMUL, United Kingdom); Rostyslav Dubrovka (Queen Mary, University of London, United Kingdom); Stuart Gregson (NSI-MI & Queen Mary, University of London, USA)

The efficiency of use of the parabolic reflector of a single offset reflector compact antenna test range (CATR) is affected largely by the illumination provided by the range feed and the reflector edge treatment with the realized quiet zone (QZ) diameter being typically as little as 30% of the diameter of the reflector. Different reflector edge treatments are commonly employed to taper the intensity of the reflected fields at the reflector aperture boundary. Such strategies mean that at higher frequencies the transverse dimensions of the QZ are unnecessarily reduced thereby decreasing the spatial efficiency of the CATR. In this paper we report preliminary results that investigate an alternative strategy that utilised a shaped beam antenna whose excitation is optimized to achieve maximum QZ size. We demonstrate that a 9-element array feeding an un-serrated rim reflector can attain a useable QZ size approaching 50% the size of the diameter main reflector.

09:00 ***Antenna and Payload Test Strategy of Large Spacecraft's in Compensated Compact Ranges***

Josef Migl and Juergen Habersack (Airbus DS GmbH, Germany); Hans-Juergen Steiner (Airbus Defence & Space & Electronics Devision, Germany)

Large compensated compact ranges are designed for antenna and payload testing of spacecraft antennas and payload units. The Compensated Compact Range concept (CCR) of Airbus does have two major advantages for such measurements. First of all a small cross-polarization (< -40 dB) for frequencies ≥ 3 GHz due to the compensating reflector design. In addition they provide a scanning capability of the test zone. The first item is a necessary condition for precise spacecraft antenna measurements at which the cross-polar performance is an important requirement. The second one, the scanning capability, is an interesting feature for deployed antennas of large spacecraft's. It can be easily utilized for antenna testing as well as radiated payload testing scenarios. This paper addresses practical implementations, achieved performance figures of the latest installations and inherent limitations by the utilization of the scanned quiet zones at a CCR test facility.

09:20 ***UHF-/P-band Antenna Measurement Capabilities at ESA-ESTEC***

Luca Salghetti Drioli (European Space Agency-ESTEC, The Netherlands); Luis Rolo and Eric van der Houwen (European Space Agency, The Netherlands)

This paper describes the challenges of performing accurate antenna measurements at low frequencies (UHF/P-band) and summarizes recent results achieved at ESA-ESTEC on near field testing of several space antennas working at those frequencies. In particular, the paper will present typical uncertainty budgets for medium gain antennas, analyzing the different contributions depending on the test set-up configuration.

09:40 ***High-Accuracy Spherical Near-Field Measurements for Satellite Antenna Testing***

Olav Breinbjerg (Technical University of Denmark, Denmark)

The spherical near-field antenna measurement technique is unique in combining several distinct advantages and it generally constitutes the most accurate technique for experimental characterization of radiation from antennas. From the conception in 1970, spherical near-field antenna measurements have matured into a well-established technique that is widely used for many wireless applications. For several of these applications, other measurements techniques would do equally well. However, for high-accuracy applications, such as remote sensing satellite missions in ESA's Earth Observation Programme with uncertainty requirments for directivity being at the level of 0.05dB, the spherical near-field antenna measurement technique is clearly advantageous. This paper addresses several aspects of high-accuracy antenna testing using the spherical near-field antenna measurement technique. This involves sources of uncertainty, measurement procedures, processing procedures, and facility validation - as well as examples of measurement campaigns with challenging uncertainty requirements for directivity and gain

10:00 ***On Orbit Performance Validation & Verification of the SMAP Instrument Antenna***

Paolo Focardi (Jet Propulsion Laboratory & California Institute of Technology, USA); Michael W. Spencer (Jet Propulsion Laboratory, USA); Jeffrey Piepmeier (NASA Goddard Space Flight Center, USA)

NASA's Soil Moisture Active Passive (SMAP) Mission is currently flying in a 685 km orbit. Featuring a Synthetic Aperture Radar (SAR) and a radiometer sharing the same antenna, SMAP was developed in collaboration between Jet Propulsion Laboratory (JPL) and Goddard Space Flight Center (GSFC). While the radar requirements on the instrument antenna were more benign from an RF point of view, the radiometer requirement were more difficult to meet because of the stability required by the radiometer to operate to its full potential. The instrument antenna performance was predicted by a very detailed RF model and verified by measuring a 1/10th scale model with great accuracy before launch. Once in orbit, we had the opportunity to measure the antenna performance for both the radiometer and the radar and compare it with the predicted performance given by our RF model.

10:20 Coffee Break

10:50 ***Performance Verification and Testing of the COWVR Instrument Antenna***

Paolo Focardi (Jet Propulsion Laboratory & California Institute of Technology, USA); David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Jefferson Harrell (Jet Propulsion Laboratory, USA); Shannon Brown (JPL-CalTech, USA)

The Compact Ocean Wind Vector Radiometer (COWVR) is a technology demonstration mission, developed at the Jet Propulsion Laboratory (JPL), and scheduled for launch in 2016. The goal of COWVR is to provide the same wind vector retrieval accuracy of other instruments, like WindSat, while reducing the total mass and using less power. In this paper, we present an overview of the COWVR instrument, and a detailed description of the EM modeling of the antenna system and the test campaign carried out at JPL to assess its performance. Special emphasis has been placed on assessing the accuracy of the predictions made with the RF model. We will show that the predicted radiation patterns are accurate enough so one can use them for orbit radiometer calibration.

11:10 ***LEO Constellation Active Antenna Test Strategy, Test Technics and EGSEs Performed During Antenna Production***

Frederic Viguier, Jérome Sinigaglia and Benoit Lejay (Thales Alenia Space, France); Eric Vourch (Thales Alenia Space France, France); Jean-Christophe Lafond and Christian Féat (Thales Alenia Space, France)

This paper deals with the test strategy, test technics and EGSEs developments in Thales Alenia Space in order to answer to the LEO constellation Active Antenna production problematic. Due to the high number of antenna to be tested, test strategy will be presented mainly based, in production phase, on conducted testing mode that lead to dedicated hardware tools able to perform RF and Telecom measurement at ambient, thermal and vacuum conditions required for such Active Antenna acceptance. Il will also be discussed how the conducted testing mode has been validated on the first antenna models (QM and PFM Antenna) by comparison between conducting and classical radiating measurement performed in Spherical Antenna Test Range. Finally, dedicated EGSEs (Electrical Ground Segment Equipments) with reproducibility and calibration constraints inherent to production testing needs will be presented.

11:30 ***Amplitude-only Calibration of an Off-axis Holography Setup for High Gain Broadband Antenna Measurements***

Ana Arboleya, Jaime Laviada and Fernando Las-Heras (Universidad de Oviedo, Spain)

In this contribution, a calibration method for broadband off-axis holography is presented. The phase of the reference antenna is retrieved in an intermediate step by using an auxiliary well known antenna, whose phase can be theoretically modeled. Therefore, the vector calibration can be bypassed yielding a process based on scalar measurements only. The proposed method can be applied to near- and far-field acquisitions and has been validated by means of a numerical example for the characterization of a parabolic reflector in the W-band.

11:50 ***Link Between Measurement and Simulation Applied to Antenna Scattering and Placement Problems***

Lucia Scialacqua and Lars Foged (Microwave Vision Italy, Italy); Francesca Mioc (Consultant, Switzerland); Francesco Saccardi (Microwave Vision Italy, Italy)

Recent use of measured data as near field sources in Computational Electro Magnetic (CEM) tools has opened the possibility to represent antennas in numerical simulations, even when the antenna characteristics and geometry are unknown and therefore cannot be included in a full wave model [1-4]. The near field source consists of an equivalent current representation of the antenna, which is prepared by the inverse source method from the measured radiation pattern [5-9]. This link bringing together numerical simulations and antenna measurements has been validated by a proper campaign, that involves MVG and different software (SW) vendors [10-15]. In the first part of this paper, the latest results of the validation are presented completing the activities described in [1-3]. In the second part of the paper, the link between measurements and simulations has been applied to more complex and/or realistic problems, including scattering problems.

TOP

IWS_02: CST Workshop - Advanced Antenna System Simulation

WG Meetings & WorkShops: Room 315

Chairs: Hassan Chreim (CST, Germany), Joao Costa (CST, Germany)

Thursday, March 23, 10:50 - 12:30

TOP

C_A01 Wideband Antennas

Cellular Communications / Regular Session / Antennas

Oral Sessions: Room 342A

Chairs: Samantha Caporal del Barrio (Aalborg University, Denmark), Guy A. E. Vandenbosch (Katholieke Universiteit Leuven, Belgium)

10:50 ***Dual-band CRLH-TL Based Patch Antenna with Pattern Diversity***

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

This paper proposes a low-profile patch antenna with pattern diversity, by combining an annular ring together with a center-fed circular patch. The dual-band operating is realized by loading a type of planar metamaterial, i.e., composite right/left-handed transmission line (CRLH-TL) on the patch. The outer ring and inner circular patch can provide broadside and omnidirectional radiation patterns, respectively. The measured correlation coefficient is lower than 0.04 and 0.05 in the lower and upper band, respectively.

11:10 ***Single-Element Handset Antenna Design for Modern Smartphones: An Industrial Approach***

Anu Lehtovuori (Aalto University & School of Electrical Engineering, Finland); Janne Ilvonen and Kimmo Rasilainen (Aalto University School of Electrical Engineering, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

In order to fulfil strict design requirements for antennas in real products, a new approach to handset antenna design is studied. In the beginning, the shape of the antenna element is fixed and the actual design is done by adjusting the position of the feeding pins and by using passive circuit elements. The designed single-element antenna covers LTE frequency bands 698-960 MHz, 1710-2690 MHz, and the high band around 3.5 GHz without tunable circuit elements.

11:30 ***Combining Antenna and Ground Plane Tuning to Efficiently Cover Tv White Spaces on Handsets***

Samantha Caporal del Barrio and Johannes Hejselbæk (Aalborg University, Denmark); Art Morris (Wispry, USA); Gert Pedersen (Aalborg University, Denmark)

With the future LTE auction for TV white spaces at 600 MHz, there is a strong need for efficient handset antennas operating at very low frequencies. This paper proposes a tunable antenna design for the low bands of LTE. In this design, not only the antenna is tuned but also the resonance of the board, thanks to using a tunable parasitic. The resulting dual-resonant antenna exhibits a peak total efficiency of -4 dB at 600 MHz.

11:50 ***A Tunable LTE Main Antenna Solution for Metallic Cover Mobile Phone***

Mark Tan (AAC Technologies PTE LTD, Singapore); Guan Hong NG and Roger Tay (AAC Technologies Pte Ltd, Singapore)

It has become a popular trend in using metallic housing for mobile phone. The metallic housing often posts a great challenge towards the design of internal antenna which is used commonly in mobile devices. As such, it has become a common practice that most will integrate the metallic housing as part of the antenna for the mobile phone. This paper presents an antenna solution for mobile phone with a metallic back cover. The antenna solution is for the Main Antenna operating at several frequency bands in the range of 700 - 960MHz, 1710 - 2170MHz, 2300 - 2400MHz as well as 2500 - 2690MHz, in the cellular network. The antenna solution presented in this paper, demonstrates the use of tunable component, integrating with the metallic housing to provide flexible tuning to cover the various frequency spectrums in the 2G, 3G and 4G cellular network.

12:10 ***A Planar GPSGLONASSLTEWWAN Antenna for Ultra-Slim Smartphones***

Aqsa Ahmad and Farooq A. Tahir (National University of Sciences and Technology, Pakistan);

Fahimullah Khan (National University of Sciences and Technology & Research Institute for Microwave and Millimeter Wave Studies, Pakistan)

A small size, planar dual wideband antenna for smartphone applications is proposed. The proposed antenna supports the multiple communication protocols including the GPS/GLONASS, DCS, PCS, UMTS2100, Bluetooth LTE2300/2500/3400 and 2.4-GHz WLAN and WiMAX 2.3/2.5/3.5GHz bands. The planar antenna is printed on 0.8mm thick FR-4 substrate and occupies the area of 30.5×9.2mm². The antenna comprises of a directly fed inverted L-shaped feeding strip, branch strip coupled to feeding strip with inductor, a inductively loaded shorted strip, and a matching circuit. In order to validate the simulation results, the designed prototype of antenna is successfully fabricated and experimentally measured.

TOP

F_A07 Antenna theory

Future Applications / Regular Session / Antennas

Oral Sessions: Room 351

Chairs: Christophe Delaveaud (CEA-LETI, France), Makoto Nagai (University of Tsukuba, Japan)

10:50 ***A New Expression for the Evaluation of the Beamwidth in 1-D Leaky-Wave Antennas: Beyond Oliner's Formula***

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 present a new formula for evaluating the half-power beamwidth (HPBW) of 1-D leaky-wave antennas (1-D LWAs). With respect to Oliner's formula, whose validity is restricted to certain hypothesis on the beam size and the pointing angle, our analysis is quite general, being accurate even when radiation points near endfire, where current formulas notably diverge. Even more interestingly, this new expression takes into account the dependence of the HPBW on different parameters, namely the length of the antenna, the pointing angle, and the attenuation constant. A simple approximate analytical formula is derived and validated through numerical results. To complete the picture, previous Oliner's formula is obtained as a limiting case of this general formulation. These results would provide a very useful tool for the correct prediction of the radiating features of 1-D LWAs.

11:10 ***Cavity-Backed Annular Conical Antenna***

Vanine Sabino (UFPE, Brazil); Odilon M. C. Pereira-Filho (Federal University of Pernambuco, Brazil)

This paper presents a full-wave solution for cavity-backed annular conical antennas. The analysis is based on equivalence principle and Method of Moments for modeling the equivalent surface magnetic currents. Numerical results for input impedance and gain patterns are shown.

11:30 ***Analysis of Superdirective Huygens Source Based End-Fire Arrays***

Alexandre Debard (University of Grenoble Alpes & CEA-LETI, France); Antonio Clemente (CEA-LETI Minatec, France); Christophe Delaveaud (CEA-LETI, France); Christopher Djoma (DGA, France); Patrick Potier (DGA/Maîtrise de l'Information, France); Philippe Pouliguen (DGA/Direction de la Stratégie, France)

In this paper, the directivity limit of end-fire arrays based on Huygens source elements has been numerically investigated. Firstly, the elementary infinitesimal Huygens source behavior is introduced and studied through Spherical Wave Expansion (SWE). Then, the maximum theoretical directivity of two-, three- and four-element arrays is calculated as a function of the inter-elements spacing. The optimization has been performed using a synthesis method based on SWE. For an inter-element spacing of a tenth of the wavelength, the obtained directivities are equal to 9.0 dBi, 11.7 dBi and 13.7 dBi for the two-, three- and four-element arrays, respectively.

11:50 ***Transmission and Reception Properties of Non-reciprocal Antennas***

Makoto Nagai (University of Tsukuba, Japan); Hiroaki Imada (Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Japan)

Most antenna theories treat an antenna is reciprocal, though non-reciprocal passive antennas are possible with gyrators and circulators. We describe basic properties of transmitting and receiving antennas which can be non-reciprocal, then related them considering thermodynamic equilibrium. An extension of the fundamental equation is derived, which is valid for any passive antennas. Based on the extended fundamental equation, we propose to define a new property of receiving antenna, reception efficiency. The reception efficiency is equal to the radiation efficiency for reciprocal antennas. The properties of a non-reciprocal passive antenna can be organized with the receiving efficiency, making transmission and reception pairs. Further, we introduce reciprocity conjugate and construct a non-reciprocal antenna model with two reciprocal antennas.

12:10 ***Characteristic Mode Analysis of Aperture Antennas Based on Duality Principle***

Peiyu Liang, Qi Wu and Donglin Su (Beihang University, P.R. China)

Characteristic mode analysis (CMA) of metallic antennas has been studied for many years. CMA of aperture antennas is usually based on the equivalent magnetic current method but the solver is not available from main-stream solvers. In this paper, the problem is studied for the first time through the duality principle. Eigenvalues, magnetic current distribution of arbitrary aperture antennas can be obtained by the CMA of its complementary form. Formulation of the method is given and the relationship between aperture and its complementary form is verified by numerical examples.

L_M01 MIMO & OTA measurements

Localization & Connected Objects / Regular Session / Measurements
Oral Sessions: Room 352B
Chairs: Jeff Frolik (University of Vermont, USA), Wim A. Th. Kotterman (Technische Universität Ilmenau, Germany)

10:50 ***Characterization of a Geometrically Constrained Tripolar Antenna Under M2M Channel Conditions***

Marcia Golmohamadi (University of Vermont, USA); Ramiro Ramirez (University of South Florida, USA); Blake Hewgill, James Jamison and Jeff Frolik (University of Vermont, USA); Thomas Weller (University of South Florida, USA)

Historically, antenna designs have been dictated by specific performance requirements for gain, beamwidth, return loss, etc. without consideration of the environment the antenna is being deployed in. Herein, we consider an over-the-air (OTA) approach for characterizing antenna performance for a wireless device arbitrarily deployed in a cluttered environment, e.g., a machine-to-machine (M2M) installation. We then explore antenna system geometries that can be cofabricated with the device's enclosure using 3D printing technologies. Based on a channel characterization study and fabrication constraints, we propose a tripolar antenna design that is readily integrated with, for example, a wireless sensor.

11:10 ***Calculating the Envelope Correlation Coefficient Directly From Spherical Modes Spectrum***

Rasmus Cornelius (RWTH Aachen University, Germany); Adam Narbudowicz and Max James Ammann (Dublin Institute of Technology, Ireland); Dirk Heberling (RWTH Aachen University, Germany)

This paper proposes an improved technique to calculate the Envelope Correlation Coefficient (ECC) by directly using the spherical mode spectrum of the antenna under test. The technique avoids errors due to numerical pattern integration and simplifies post-processing for near-field measurements. The technique is successfully tested on two different antenna types, in the total number of four MIMO configurations.

11:30 ***Evaluation of a Simplified Random-LOS Measurement Setup for Characterizing Antennas on Cars***

Madeleine Schilliger Kildal (Chalmers University of Technology & Bluetest AB, Sweden); Andrés Alayon Glazunov (Chalmers University of Technology, Sweden); Jan Carlsson (Provinn AB, Sweden); Amir Majidzadeh (Volvo Car Corporation, Sweden)

The automotive industry is in need of reliable, accurate yet cost-effective over-the-air (OTA) characterization methods of the communications systems installed on cars. This paper analyses the scattering contributions to spurious variations of receive signals in a Random Line-of-Sight (Random-LOS) measurement setup in a semi-anechoic chamber. Figures of merit are the delay spread and the dynamic variations of the receive signals. Transmission measurements were performed on a two-element LTE shark-fin antenna mounted on the roof of a Volvo XC90. We show that by using a vertically oriented uniform linear array, with vertically polarized bowtie antenna elements, we can efficiently remove the unwanted ground reflection present when a single bowtie antenna is used. We also show that the improvement depends on the position of the antennas mounted on the car as well as on the azimuthal angle.

11:50 ***Evaluation of Array Antenna Systems for GNSS Applications Using Wave-Field Synthesis in an OTA Laboratory***

Christopher Schirmer (Technische Universität Ilmenau, Germany); Alexander Rügamer (Fraunhofer IIS, Germany); Wim A. Th. Kotterman (Technische Universität Ilmenau, Germany); Markus Landmann (Fraunhofer Institute for Integrated Circuits IIS, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany)

Antenna characterization is usually performed by antenna pattern measurements in an anechoic chamber. Subsequently, a conducted test, the Radiated Two-Stage (RTS) or the Wireless-Cable method can be used for an overall system test considering the measured patterns. In this paper we present a method to perform device tests for antenna arrays / smart antennas without the need of radiation pattern measurements, and we validate it experimentally. By using Over-The-Air tests in a Virtual Electromagnetic Environment and Wave-Field Synthesis, the propagation environment can be realistically recreated in the region around a Device-Under-Test. This allows for reproducible performance comparisons of different antennas or systems under identical propagation environment conditions. As a special application, we consider the Controlled Reception Pattern Antenna (CRPA) in a Global Navigation Satellite Systems environment in the presence of interferer signals.

12:10 ***Extending the Frequency Range of Reverberation Chamber to Millimeter Waves for 5G Over-the-Air Testing***

Christian Lötbäck (Bluetest AB, Sweden)

The wireless industry is getting deeply engaged in the 5th generation communication standard. Despite lack of clear definitions, there are some parameters of the emerging standard which are commonly accepted. Higher frequencies (frequencies above 6 GHz) in the millimeter wave spectrum will be a key component for enabling a massive increase of the available bandwidth and thus data rates for the end users. This will however impose challenges on the test equipment for the wireless devices operating on these frequencies. The Over-the-Air test

facilities used today for 4G and legacy standards are optimized for operation below 6 GHz. A frequently used tool for Over-the-Air performance assessment is the reverberation chamber. This paper will analyze the feasibility of the reverberation chamber to be extended to the frequencies considered for 5G.

Thursday, March 23, 13:30 - 15:00

TOP

Poster_06

Cellular Communications / Regular Session / Antennas
Room: Poster Sessions: Corridor Neuilly
Chairs: Jari Holopainen (Aalto University School of Electrical Engineering, Finland), Julien Sarrazin (University of Pierre & Marie Curie UPMC, France)

An Antenna for a Cell Phone

Boris Levin and Michael Kondratiev (Holon Institute of Technology, Israel)

In the article new antenna for personal cell phones is offered. This antenna allows to satisfy high requirements to the antennas of mobile phones: compactness, high efficiency, multi-frequency operation and also low level of user's head irradiation. Design principles and electrical characteristics of the offered antenna are described. Characteristics of the new antenna and characteristics of known antennas are compared with each other.

Enabling Spatial Diversity and Beamsteering with Reduced RF-chains Using Reconfigurable Transmitarrays

João Ricardo Reis, Jr (University of South Wales & WORIC - Wireless and Optoeletronics Research and Investigation Centre, United Kingdom); Rafael F. S. Caldeirinha (IPL - Polytechnic Institute of Leiria & Instituto de Telecomunicação (IT), Portugal); Telmo R. Fernandes (IPLeiria / Institute of Telecommunications & ESTG/IT-DL, Portugal); Akram Hammoudeh (University of Glamorgan, United Kingdom)

This manuscript introduces a new vision on the implementation of spatial diversity with beamsteering capability, by suppressing the typical beamforming networks of antenna phased arrays and replace them by Reconfigurable Transmitarrays. Consequently, the radio frequency components, i.e. RF-chains that compose such systems, were replaced by a device with the capability to perform two-dimensional beamsteering relying on single antenna source, hence reducing the number of associated RF hardware in comparison with traditional phased array systems. By spatially distributing side-by-side more than one device, spatial diversity with beamsteering is enabled with an estimated reduction of 1:8 in the number of associated RF-chains. This new concept clearly demonstrates its merit by directly reducing the implementation costs,, RF-chain components and increasing the energy efficiency, specially in larger systems.

Liquid-crystal-tunable Metasurface Antennas

Senglee Foo (Huawei Technologies Canada, Canada)

This paper presents a new concept of electronically tunable metasurface using nematic liquid crystal. The proposed metasurface is a high impedance surface that contains electrically small scatteres loaded with liquid crystal, distributed in a periodic two-dimensional plane with a relatively small periodicity as compared to the operating wavelength. Distribution of reflection phase on the metasurface is reconfigurable by varying DC voltages on unit cells across the metasurface. This tunable metasurface concept can be useful for development of relatively large, electronically tunable, beam steering antennas, especially for millimeter wave applications.

A Dielectric Resonator Antenna Over Corrugated Ground Plane with Metallic and Nonmetallic Metamaterial Superstrates

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

In this paper, some applications of metamaterial superstrates for directivity enhancement of cylindrical dielectric resonator antenna (DRA) mounted on corrugated ground plane are investigated. Three different types of superstrates, viz., split ring resonator (SRR), S-shape, and cubic high dielectric resonator (CHDR) are discussed. The metamaterial structure is used as a lens to improve the directivity of DRA and the corrugated ground to suppress back lobes.

Small Metasurface Reconfigurability

J (Yiannis) Vardaxoglou (Loughborough University, United Kingdom)

A small unit cell frequency tunable MetaSurface (MS) is studied. The MS comprised of a double layer array with square conducting patches on one layer and meanderline slots on the other. The reconfigurabilty (frequency tuning) has been achieved by four varactor diodes placed symmetrically across the meandered slot on the ground plane. An efficient biasing circuit has been designed to control all the varactors where simulation results show that, by tuning the varactors from 4.08 pF to 0.95 pF, the operating frequency of the MS can be tuned from 1.08 to 1.61 GHz.

Compact Reconfigurable Antenna with Radiation Pattern Diversity for Spatial Modulation

Abdelwaheb Ourir and Kammel Rachedi (Institut Langevin ESPCI Paris CNRS, France); Dinh-Thuy Phan-Huy (Orange-France Telecom, France); Christian Leray (Time Reversal Communications SA, France); Julien de Rosny (Institut Langevin, Valenciennes, France)

We design a compact reconfigurable antenna suitable for integrable communication systems based on spatial modulation. This recent technique is a simple implementation of multiple-input multiple-output communication

scheme. The reconfigurable antenna is based on a meander line radiating element surrounded by two L-shaped wire resonators connected to a metallic ground plane with two PIN diodes. By switching these last, this subwavelength (lambda=5) printed antenna can generate four different radiation patterns. The cross-correlations between the different patterns range between 11% to 80% that match the requirements of spatial modulation. To increase the number of patterns, two other geometries are proposed.

A 30GHz High-Gain Circularly-polarized Pattern-Steerable Antenna Based on Parasitic Patches

Mohammad Akbari (Concordia University & Montreal, Canada); Mohammadmahdi Farahani (INRS University, Canada); Abdel R. Sebak (Concordia University, Canada); Tayeb A. Denidni (INRS-EMT, Canada)

This paper represents an aperture-coupled circularly polarized (CP) microstrip patch antenna with four parasitic elements around the radiating patch. Four parasitic elements are applied to improve the antenna directivity. In order to generate CP electromagnetic wave, a cross-shaped slot is etched off the patch's metal ground surface. The beam reconfiguration is obtained using the metal shorting p-i-n diodes, which is placed between the parasitic elements and the planar ground. To further enhance the antenna gain and CP bandwidth, the paper also presents simulated results for an antenna array based on parallel sequential feeding technique.

Millimeter Wave Antennas for Backhaul Networks

Jose Enriquez Gonzalez and Xavier Begaud (LTCI, CNRS, Télécom ParisTech, Université Paris-Saclay, France); Bernard Huyart (TelecomParisTech, France); Quang Trung Le (HF Systems Engineering GmbH & Co. KG, Germany); Ralp Zimmerman (HF System Engineering, Germany); François Magne (WHEN-AB & SARL, France)

Nowadays, the increasing demand for capacity in telecommunication systems forces cellular network operators to develop new backhaul solutions. The millimeter wave band technology is one of the most promising solutions to support the increasing flux of data and to replace long deployment time and cost of optical fiber. Thus, the goal of the H2020 TWEETHER project is to provide access to fiber using wireless Point-to-Multipoint architecture in the millimeter wave band. In this paper, the design of the required antennas in the framework of the TWEETHER project is presented.

Ridge Gap Waveguide Slot Antenna Array with 30% Bandwidth for 60-GHz Applications

Ali Farahbakhsh (Graduate University of Advanced Technology, Iran); Davood Zarifi (University of Kashan, Iran); Ashraf Uz Zaman (Chalmers University of Technology, Sweden)

This paper presents a wideband high efficiency slot antenna array based on ridge gap waveguide technology at 60 GHz for millimeter-wave applications. The antenna sub-array consists of four radiating slots that are excited by a cavity. Some tuning pins are placed inside the cavity to achieve wideband performance. A 4×4 slots array antenna is designed using 4-ways power divider. The proposed structure exhibits 30% impedance bandwidth (|S11| ≤ -10 dB) covering form 50 GHz to 67.8 GHz. The gain up to 21.5 dBi is obtained with total efficiency more than 90%.

Analysis and Design of Metallic Parabolic Anechoic Chamber

Ali Farahbakhsh (Graduate University of Advanced Technology, Iran); Davood Zarifi (University of Kashan, Iran)

Anechoic chambers are used for indoor antenna measurements. The common method for anechoic chamber construction is to cover all inside walls by the electromagnetic absorbers. In this paper, a fully metallic parabolic chamber structure is presented in which the propagation of the electromagnetic waves inside the chamber is controlled and they are guided to an absorber. In the proposed method, an appropriate quiet zone with plane wave illumination is obtained and unlike ordinary anechoic chambers, the absorber usage is decreased greatly. The performance of the chamber is evaluated by simulation. The results showed that the proposed method could provide a useful technique for the indoor antenna measurements.

Flexible and Conformal Printed Monopoles for Reconfigurable Antennas

Asmae Hachi (FST Mohammedia, Université Hassan II de Casablanca, Morocco); Hassan Lebbar (FST Mohammedia, Université Hassan II de Casablanca, France); Mohamed Himdi (Université de Rennes 1, France)

This paper presents the development and design of flexible and conformal printed monopoles for reconfigurable antennas. The main objective is to control the level of radiation in broadside antenna from zero to a maximum by changing the curvature of printed board. Two printed antenna types are considered: thin wire and disk monopole. In the further, with curving radius R increasing, the classical null on the broadside radiation pattern disappears gradually for both wire and disk. Increasing the curvature radius of conformal flexible antenna, and keeping all other parameter's value, wire monopole antenna become mismatched while the disk monopole antenna remains matched for all radius of curvature. The simulated results of various monopoles are compared successfully with measurements.

Low Cost Instantly Printed Silver Nano Ink Flexible Dual-Band Antenna onto Paper Substrate

Husameldin Elmobarak and Sharul Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia); Mohamed Himdi (Université de Rennes 1, France); Xavier Castel (IETR-Université de Rennes 1, France); Tharek Abdul Rahman (Wireless Communication Centre, Malaysia)

An instant and low cost inkjet-printed multi -band Sierpinski fractal antenna onto a flexible paper substrate using chemically sintered silver nanoparticles ink is demonstrated in this study. The printed layers are highly conductive seconds after printing in room temperature without the need for special equipment's or processes. An on shelf ink jet printer is used to print the antenna precisely. The antenna operates effectively at (1.5 GHz to 2.7 GHz) and (5.1 GHz to 11 GHz) bands. It has showed highly flexible mechanical properties enable it to be bent without sacrificing the performance dramatically. The promising results indicates the potential of utilizing instant printing technology for instantly and efficiently integrating antennas with flexible electronics and systems for future wireless networks.

Triple-Wideband Inverted-F Frame Antenna for the LTE Metal-Casing Smartphone

Li Yu Chen and Yu-Ching Wu (National Sun Yat-sen University, Taiwan); Kin-Lu Wong (National Sun Yat-Sen University, Taiwan)

A frame antenna based on the inverted-F antenna (IFA) structure for the LTE (long term evolution) metal-casing smartphone is presented. The antenna uses a frame section along the short edge of the metal casing as the IFA's radiating strip. There are no gaps required at the two side edges of the smartphone. The frame section is connected to a feed circuit board (FCB) to achieve wider bandwidth. With a narrow metal clearance of 2 mm in the metal back cover, the antenna can provide a triple-wideband LTE operation to cover 824~960 MHz, 1710~2690 MHz, and 3400~3800 MHz bands. Moreover, by selecting different inductances of the inductor at the shorting strip of the IFA, the low band of 704~960 MHz can be covered. Details of the proposed antenna structure and its working principle are described, and experimental results of the fabricated antenna are presented.

Compact LTE Frame Antenna with a Narrow Metal Clearance and a Radiating Feed Network for the Metal-Casing Smartphone

Hsuan-Jui Chang (National Sun Yat-sen University, Taiwan); Kin-Lu Wong (National Sun Yat-Sen University, Taiwan)

A compact LTE frame antenna with a 2-mm narrow metal clearance for the metal-casing smartphone is presented. The antenna requires only a radiating metal frame section of about a half of the short edge of the smartphone. The metal frame section is fed by a radiating feed network, which includes a feed network and two radiating branches. The feed network includes an inductive feed path (L-path), a capacitive feed path (C-path) and a matching circuit. By feeding the metal frame section through the L-path and C-path, a fundamental mode at low band and a dual-resonance mode at high band are generated. Radiating branches offer additional resonant modes to combine with the fundamental mode and the dual-resonance mode contributed by the radiating metal frame section to cover the LTE low band and the LTE high band. The antenna structure, operation principle, and the experimental results of the proposed antenna are presented.

LTE Handset Antenna with Closely-Located Radiators, Low-Band MIMO, and High Efficiency

Kimmo Rasilainen (Aalto University School of Electrical Engineering, Finland); Anu Lehtovuori and Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

Performance of a multi-element handset antenna operating at LTE frequencies is reported. The antenna elements have metal parts that are closely located physically and electrically. Matching circuits are used to reduce mutual coupling and to improve the efficiency. With a combination of active and reactively loaded radiators and fixed matching circuits, an embedded radiation efficiency better than 80 % at 698-960 MHz and better than 60 % from 1.7 GHz upwards is achieved. By using identical antennas in both ends of the device, two-element Multiple-Input Multiple-Output (MIMO) operation can be obtained in simulations with efficiencies up to 60 % at low band and better than 60 % at high band.

A Study of 5G Antennas in a Mobile Terminal

Jari Holopainen and Jari-Matti Hannula (Aalto University School of Electrical Engineering, Finland); Ville Viikari (Aalto University & School of Electrical Engineering, Finland)

This paper presents a simulation-based study for the number and placement of 5G antenna elements in mobile terminals operating in the frequency range from 1 to 6 GHz. Different antenna configurations are compared in terms of the ergodic capacity (bit/s/Hz) in the spatial multiplexing mode. According to the results, ergodic channel capacity increases almost linearly with the number of antenna elements at least up to 10 elements in a device at all the studied frequency.

Tuning of LTE Main Antenna Using Flexible Tunable LC Resonant Circuitry

Mark Tan (AAC Technologies PTE LTD, Singapore); Guan Hong NG and Roger Tay (AAC Technologies Pte Ltd, Singapore)

There have been an increasing trend in using metallic housing for mobile phone. The metallic housing can comes in many different forms ranging from a metal frame/rim that goes around the side of the mobile phone; to metal frame/rim with slots cut on it; to a full metallic back cover covering the back and side of the mobile phone. These metallic housing improves the outlook appearance of the mobile, and adds mechanical strength for the mobile phone. However, from the antenna point of view, such metallic housing often posts a great challenge towards the flexibility in designing the antenna and reduces the antenna sensitivity performance. This paper presents approaches of overcoming the challenges by introducing Tunable Circuitry that can be applied on both Aperture Tuning and Impedance Matching of the antenna in mobile phone with metallic back cover.

Multiband Non-Resonant Antenna System with Reduced Ground Clearance

Aurora Andújar, Jaume Anguera and Rosa Mateos (Fractus, Spain)

Small and multiband antennas are crucial elements for wireless devices. On one hand, the space devoted to the antenna is small due to the presence of other electronic components in the device. On the other hand, the number of frequency bands with the inclusion of 4G is relevant. In order to achieve a small and multiband antenna, a strategy using a non-resonant element in combination with a passive multiband matching network is proposed. Also, in order to facilitate the integration of other electronic components in the device, the ground clearance is reduced and its impact on efficiency has been evaluated. The feasibility of the proposal is analyzed both in the simulation domain as well as with a prototype to validate the results. The architecture comprises a non-resonant element of 12mmx3mmx2.4mm (h) operating at 824MHz-960MHz and 1710MHz-2690MHz with a ground clearance of 20mm x 11mm suitable for smartphones.

Design of Compact Printed Antennas for 5G Base Stations

Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Fabrizio Robol (ELEDIA Research Center, Italy); Alessandro Polo (ELEDIA Research Center, University of Trento & ELEDIA Research Center, University of Trento, Italy); Renato Lombardi (Milan Microwave Competence Center, Italy); Men Chuan (HUAWEI Technologies, P.R. China); Maurizio Mattivi,

Claudio Massagrande and Pietro Vinetti (HUAWEI Technologies, Italy); Christian Mazzucco (Huawei Technologies, European Research Center, Italy); Andrea Massa (University of Trento, Italy)

An innovative massive multi-objective design procedure is proposed for the synthesis of next-generation antennas for 5G base stations. The 5G antenna design problem is formulated by jointly considering several contrasting requirements in terms of bandwidth, directivity, half-power beamwidth, polarization, and neighbor element isolation. Towards this end, a finite-array model is developed which enables the simulation of a set of adjacent elements during the design process. Thanks to such an approach, the obtained design can be directly included in 5G antenna arrays without further re-optimization to compensate for mutual coupling effects. The resulting massive multi-objective problem is recast as a multi-objective one by suitably clustering the cost function terms according to their physical features, and ad-hoc global search techniques are customized and applied in order to address with the obtained highly non-linear optimization problem. Preliminary numerical results concerning a Pareto- optimal tradeoff solution are presented to validate the proposed approach.

A Honeycomb-Shaped Planar Monopole Antenna for Broadband Millimeter-wave Applications

Hidayat Ullah (National University of Science and Technology, Pakistan); Farooq A. Tahir (National University of Sciences and Technology, Pakistan); Muhammad Umar Khan (National University of Sciences and Technology & School of Electrical Engineering and Computer Science, Pakistan)

This paper investigates a planar monopole antenna for fifth generation (5G) wireless communication networks. The proposed antenna has an ultra-wide band impedance response in millimeter wave (mmW) spectrum, 25-39 GHz covering Ka band. The antenna has unique structural layout resembling hexagonal honeycomb and has low profile (87 mm2) on 0.254 mm thick Rogers substrate, enabling the design for incorporation into future mobile phones. This antenna provides peak gain of 4.15 dBi along with 90% efficiency in the working band. The design is also extended to an 81 element array presenting maximum gain of 12.7dBi at central frequency of the antenna.

Feasibility of Perpendicular-Corporate Feed for a Multi-Layered Parallel-Plate Slot Array Antenna

Hisanori Irie and Jiro Hirokawa (Tokyo Institute of Technology, Japan)

This paper presents the feasibility of perpendicular-corporate feed for a multi-layered parallel-plate slot array antenna, where the coupling apertures are fed by a corporate feed circuit and each of the coupling apertures excites 2x2 radiating slots with additional one from the bottom to the top of the multi-layer parallel plates. Dielectric with proper permittivity is placed between the coupling aperture layer and the radiating slot layer to excite a standing wave to prevent leakage. A 2x2-element subarray fed by a waveguide provides 4.9 % bandwidth for VSWR ≤ 1.5 by the additional slot layer.

Phase Error Effects on Distributed Transmit Beamforming for Wireless Communications

Yuan Ding (Queen's University Belfast & The ECIT, United Kingdom); Vincent Fusco and Junqing Zhang (Queen's University Belfast, United Kingdom)

This paper investigates the impact of phase errors of beamforming networks on the performance of distributed transmit beamforming systems. Through multi-tone signal, wider band, models and the defined phase error percentage (PEP) of the beamforming networks, the distorted signal waveforms for different wider band occupying beamforming systems are presented. Furthermore, simulated bit error rates (BERs) are obtained to illustrate how the distributed array aperture sizes, the signal bandwidths, the PEPs, and the signal to noise ratios (SNRs) interact with each other. These studies are then used to provide some guidelines for wideband distributed transmit beamforming system design.

Mimetized Printed Yagi-Uda Antenna Array for TDT Reception

Jorge Gómez-Yuste (Universitat Politècnica de València); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Eva Antonino-Daviu (Universidad Politecnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

A printed Yagi-Uda antenna composed of a planar driven dipole, a planar reflector and two planar directors is presented. The antenna is fed by using a printed transmission line formed by two parallel printed lines that act as a balun. The printed Yagi-Uda is well matched within the TDT operating band, exhibits compact size, and provides gain values close to 6 dBi. In order to increase the gain, a 4-element vertical array of printed Yagi-Uda antennas is proposed. The performance of this uniform linear vertical array is similar to that of commercial wire Yagi-Uda antennas. Due to the compact size of the elements, the vertical array can be easily mimetized as a chimney or ventilation pipe. The proposed design reduces the visual impact of classical antennas used for TDT reception, being especially attractive for historical buildings or residential houses in which aesthetic appearance is of great importance.

Test Bed for Beamforming in LTE-Advanced

Mohammad Haroun (Lebanese University, Lebanon); Marta Cabedo-Fabrés (Universidad Politécnica de Valencia, Spain); Hussam Ayad and Jalal Jomaah (Lebanese University, Lebanon); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

In this paper, a test bed for LTE-Advance Beamforming is proposed. The test bed is composed of an 8x1 monopole antenna array matched at the mid and higher bands for LTE operating in Europe, wide band transceivers with agile architectures provided by Analog Devices, and mid range FPGA from Xilinx for antenna weight calculation and beamforming on the fly. The test bed is promising to give a useful mean for research in exploitation of beamforming for LTE services.

Impact of Phase Compensation Method on Transmitarray Performance

Fatimata Diaby (Université Grenoble-Alpes & CEA, France); Antonio Clemente (CEA-LETI Minatec, France); Luca Di Palma (Space Engineering S.p.A., Italy); Laurent Dussopt (CEA, LETI,

Minatec, France); Ronan Sauleau (University of Rennes 1, France)

The impact of the phase compensation method on transmitarray (TA) performance is studied here in terms of directivity, gain, aperture efficiency, and beam scanning capability. The analysis has been done by considering generic TAs based on ideal unit-cells and illuminated by an ideal focal source with a gain of 10-dBi and 100% of efficiency. The phase compensation on the array aperture can be implemented using two different methods, namely constant phase-shift and True Time Delay (TTD). The numerical results show that TTD compensation allows increasing the TA bandwidth and reducing beam squint as compared to constant phase-shift compensation.

Switched-Beam E-Band Transmitarray Antenna for Point-to-Point Communications

Laurent Dussopt (CEA, LETI, Minatec, France); Amazir Moknache (CEA, France); Thomas Potelon (IETR - University of Rennes 1, France); Ronan Sauleau (University of Rennes 1, France)

Switched-beam transmitarray antennas operating at E band (71-76 GHz and 81-86 GHz) are investigated in the perspective of self-alignment applications for point-to-point wireless communication links, which play an increasing role in modern mobile networks infrastructures. Several designs are presented covering either one or both sub-bands. Simulation results exhibit promising performance with gain levels in the range of 31-35.1 dBi for a 100-mm diameter aperture. The design of a switched focal array is presented and enables the coverage of an angular sector of ±6.6° with 5.1 dB gain variation in the lower band and ±6.9° with 6.8 dB gain variation in the upper band.

Averaging Phase Elements of a W-band Reflectarray with Printed Source

Brice Delanoe (University of Nice Sophia-Antipolis, France); Jerome Lanteri and Claire Migliaccio (Université Nice Sophia Antipolis, France); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France)

In the perspective of backhaul applications, this paper discusses the design of a reconfigurable single layer millimeter-wave reflectarray fed by a printed source using averaging phase elements.

A Miniaturized Dual-band Stop Frequency Selective Surface for 900 MHz and 1800 MHz Bands Shielding

Mudassar Nauman (Lahore University of Management Sciences (LUMS), Pakistan); Wasif Khan (LUMS & LUMS, Pakistan)

In this paper a new and miniaturized dual-band stop frequency selective surface (FSS) is presented. The unit cell of the proposed FSS consists of two convoluted square loop (CSL) elements printed on either side of dual layered FR-4 laminate. Inwards and outwards T-shape stubs (TSSs) are introduced on each side of conventional square loop elements. With the introduction of TSSs in the geometry 18.1% miniaturization has been achieved. The proposed FSS exhibits good 3-dB fractional bandwidth of 43.4% and 31.5% with attenuation of at least 37-dB for 900 MHz and 1800 MHz bands. The scattering parameter S_21 is also analyzed at the selected band-stop frequencies. In addition, the proposed FSS structure provides a stable frequency response at oblique angles of incidences. In comparison to the conventional square loop FSS, the proposed FSS provides 70.1% and 67.8% stable response at 900 MHz, for TE and TM modes, respectively.

A Pattern Reconfigurable Microstrip Dipole Antenna with PRS Gain Enhancement

Beyit Barakali, Kenneth Lee Ford and Salam Khamas (University of Sheffield, United Kingdom)

This paper investigates a low complexity high gain structure that can switch the radiation pattern from boresight to almost endfire direction. The principles of Fabry Perot, reconfigurable parasitic reflectors and partially reflective surfaces are combined to achieve the pattern reconfigurability. Two different Fabry-Perot cavity spacings are assessed and a maximum gain of 18.8 dBi is achieved at boresight which can be reduced by over 12dB with the use of PIN diode switches. Radiation towards the endfire directions has a maximum gain of 7.1dBi which can be reduced by almost 17dB with the use of the PIN diode switches. The paper presents numerical simulations of the proposed antennas.

A Reconfigurable Beam Dual Polarized Microstrip Cross Patch Antenna

Assane N'gom (Université Cheikh Anta Diop de Dakar, Senegal); Aliou Diallo (University of Nice, France); Kharouna Talla and Abdoulaye Chaibo (Université Cheikh Anta DIop de Dakar, Senegal); Ibra Dioum (Ecole Supérieure Polytechnique – Université Cheikh Anta Diop, Senegal); Jean Marc Ribero (University of nice & LEAT, France); Aboubaker Chedikh Beye (Université Cheikh Anta DIop de Dakar, France)

this paper presents the conception of a reconfigurable beam antenna with horizontal or vertical polarization for millimeter-wave multi-beam small cells array purposes for 5G systems. This new structure consists of one driven cross patch surrounded by four parasitic elements. In each parasitic element one shorting switch is used to change the beam direction. The parasitic elements can be considered either reflector or director. Specifically, a new method of the feeding microstrip antenna consists in connecting two coaxial probes alternate ON or OFF in one driven element. By combining the states of the four shorting switches with the probe feeding, three beam patterns can be obtained in each orthogonal plane with 3dB-beamwidth of 178° at frequency 10GHz. The simulated and measured results of S parameter and radiation patterns are presented.

Dual-Band 8-Element MIMO Antenna with Short Neutral Line for 5G Mobile Handset

Xueliang Shi, Ming Zhang, Su Xu, Daqing Liu, Huailin Wen and Jun Wang (Huawei Technologies Co. Ltd, P.R. China)

A compact dual band 8-element MIMO antenna using folded monopole structures is proposed. The MIMO antenna consists of 8 folded monopole antenna elements, each two are symmetrically placed on the orthogonal frame corners of the substrate, and closely located to each other with no clearance on the ground. The folded arms are used as radiation elements to resonate at two different bands of 3.4-3.6 GHz and 4.55-4.75 GHz. Each closely placed two antenna elements are connected by a 3 mm short neutral line which can be used to reduce the mutual coupling at both bands. By optimizing the antenna structure and neutral line, dual band decoupling can be achieved. The isolation and efficiency of the MIMO antenna is improved and the calculated ergodic channel

capacities with 20 dB SNR at both bands reach to 41.2 bps/Hz and 40.3 bps/Hz, respectively, very close to the ideal case of 8×8 MIMO system.

A Decoupling Technique for the Design of Strongly Isolated Closely Spaced Antennas

Lamia Sadaoui (Nice Sophia Antipolis University, France); Georges Kossiavas (University of Nice, France); Robert Staraj (University of Nice-Sophia Antipolis, France)

This paper presents a technique for decoupling close radiating elements printed on FR-4 substrate designed for the [0.7-0.9] GHz LTE low frequency band. This is obtained by using a power splitter and a phase shifter connected between the feeds of two symmetrical antennas surrounding a third one. This method provides a high isolation of 70 dB at the center frequency of 0.81 GHz between the feed port of the central element and the feed port of the two monopole array. A prototype is realized and tested. The measurements are in good agreement with the simulated results.

Low Losses Printed Distribution Network Technologies for Planar Antennas in Ka Band

Adrián Tamayo-Domínguez (Universidad Politecnica de Madrid, Spain); José-Manuel Fernández-González and Manuel Sierra-Pérez (Universidad Politécnica de Madrid, Spain)

Study of Substrate Integrated Waveguide and Gap Waveguide technologies used to manufacture some demonstration prototypes at Ka band for a low losses distribution network in a low profile antenna. A transmission losses comparison is presented using lossy and lossless dielectric substrates in the simulations for the different technologies at 30 GHz. Various structures such as transitions from WR-28, bends, and power dividers have been designed and simulated. The simulations of different models are compared with the manufactured prototypes in metallized 3D-printed plastic technology and in RO4350B and FR-4 substrates for a band from 28 to 30 GHz.

Heuristic UTD Coefficients for Delay Spread Prediction in an Indoor Scenario

Andres Navarro (Universidad Icesi, Colombia); Dinael Guevara (Francisco de Paula Santander University, Colombia); Narcis Cardona (The Polytechnic University of Valencia, Spain); Jorge Gomez (Universidad del Magdalena, Colombia)

This paper presents a comparison of two heuristic coefficients for the Uniform Theory of Diffraction (UTD), used to estimate multichannel parameters in indoor environments. The coefficients were implemented in a model based on 3D ray-launching techniques in a meeting room. In order to evaluate each coefficient we analyze the statistical behavior of the mean and standard deviation of the errors between the estimated values and the measured data of the mean excess delay and the rms delay spread. Additionally, we analyze the effect on delay spread estimated when considering adjusted values of material's permittivity. Finally, we show the delay spread prediction for each UTD heuristic coefficients proposed.

Doppler Spectrum and Second Order Fading Statistics of Emerging 3-D Radio Cellular Propagation Channels

Abrar Ahmed (COMSATS Institute of Information Technology, Pakistan); Sardar Muhammad Gulfam (Comsats Institute of Information Technology, Pakistan); Junaid Nawaz Syed (COMSATS Institute of Information Technology, Islamabad, Pakistan); Mohammad N Patwary (Staffordshire University, Stafford, United Kingdom)

In implementing fifth generation (5G) networks, the advancements in density of networks, cell size, scale of antenna arrays, communicating nodes mobility, and range of frequencies necessitate to derive a reliable and appropriate channel model. A geometric three dimensional (3-D) tunable channel model is proposed with high degree of flexibility in modelling the orientation, shape, and scale of the scattering region and comprehending the mobility of user terminal. Characterization of Doppler spectrum, and second order fading statistics of the radio propagation channel is presented. Expressions for probability density function (PDF) of Doppler shift and multipath power are derived. The impact of various physical channel parameters on statistical characteristics of Doppler spectrum and second order fading statistics is analyzed.

Wideband Channel Fading Characteristics in Corridor Environment at Millimeter-Wave Bands

Tianyi Wu, Haiming Wang, Chen Yu and Wei Hong (Southeast University, P.R. China)

The channel measurement and modeling of fading characteristics of 25.5 and 39.5 GHz bands in corridor environment are investigated. An automatic measurement system owning a sufficient dynamic range is designed to overcome the prominent attenuation in the millimeter-wave band. After conducting extensive measurements, large-scale and small-scale fading characteristics are obtained and compared. Good-of-fit test is applied to validate whether the assumed log-normal distribution can describe the shadow fading characteristics. The closed-in log-distance path loss model and the least-square fitted model are respectively employed to analyze the effects of frequency and antenna polarization on large-scale fading. Besides, typical small-scale fading parameters such as root-mean square (RMS) delay spread and in-cluster RMS angle spread are extracted utilizing the bisecting k-means clustering algorithm.

Basestation 3-Dimensional Spatial Propagation Characteristics in Urban Microcell at 28 GHz

Tao Jiang (Beijing University of Posts and Telecommunications, P.R. China); Lei Tian (Beijing University of Posts and Telecommunications & Wireless Technology Innovation Institute, P.R. China); Pan Tang, Zhixue Hu and Jianhua Zhang (Beijing University of Posts and Telecommunications, P.R. China)

This paper presents a millimeter wave channel measurement in Urban Microcell (UMi) scenario at 28 GHz with a bandwidth of 400 MHz. During measuring, a steerable horn antenna is used at receiver (RX) side while an omnidirectional antenna is used at transmitter (TX) side. The horn antenna not only rotates in azimuth with a step of 5◦ but also points into three different vertical angles. Based on the measured data, the 3-dimensional (3D) space characteristics of the millimeter wave channel are analyzed at the basestation (BS) side, e.g., azimuth angular spread of arrival (AASA), elevation angular spread of arrive (EASA) and their clustering results, by using the Space-Alternating Generalized Expectation-maximization (SAGE) algorithm and KPowerMeans algorithm. By comparing the power angular profiles (PAPs) of raw data (RD) and SAGE results, the dynamic range of SAGE results will

increase. The positive correlation between the measured distance and EASA is also investigated here.

Performance Comparison of 4G and Massive MIMO Network Configurations Using Heuristic and Metaheuristic Approaches

Sotirios Goudos (Aristotle University of Thessaloniki, Greece); Margot Deruyck (Ghent University / IBBT, Belgium); David Plets (Ghent University - iMinds, Belgium); Luc Martens (Ghent University, Belgium); Wout Joseph (Ghent University/IMEC, Belgium)

The reduction of power consumption in wireless access networks is a challenging and important issue, which will also play an important role in future cellular systems. Massive MIMO (multiple-input multiple-output) is one of the key technologies to handle orders of magnitude more data traffic and to be included in the fifth generation (5G) cellular systems. In this paper, we compare 4G and Massive MIMO network configurations. Our main objective is to reduce power consumption by responding to the instantaneous bit rate demand by the user. We study the application of a capacity-based heuristic and an evolutionary algorithm (EA) to the above-mentioned network design problem. Moreover, we introduce a new hybrid approach that uses both an EA and concepts from the capacity-based heuristic. We compare and discuss the preliminary results of both technologies.

Spatially Separated Single-Polarized vs. Collocated Dual-Polarized MIMO Measurements

Viktor Nikolaidis (University of Piraeus, Greece); Nektarios Moraitis (National Technical University of Athens & Institute of Communications and Computers Systems, Greece); Athanasios G. Kanatas (University of Piraeus, Greece)

This paper presents the preliminary results of multiple-input-multiple-output (MIMO) channel measurements, comparing a collocated dual-polarized reception system and a classical MIMO system, having spatially separated single-polarized antennas. The measurement campaign considers a land mobile satellite (LMS) pedestrian scenario in an urban environment.

Spatial Consistency of Dominant Components Between Ray-Tracing and Stochastic Modeling in 3GPP High-Speed Train Scenarios

Ke Guan, Guangkai Li, Danping He and Longhe Wang (Beijing Jiaotong University, P.R. China); Bo Ai (Beijing Jiaotong University & State Key Lab of Rail Traffic Control and Safety, P.R. China); Ruisi He and Zhangdui Zhong (Beijing Jiaotong University, P.R. China); Li Tian and Jianwu Dou (ZTE Corporation, P.R. China)

In reality, the dominant components (the specular rays with larger power) of wireless channels should be contiguous and smoothly changing over positions. However, such spatial consistency cannot be guaranteed if the channel is modeled in a purely stochastic way. In this paper, through two series of simulations, we study the spatial consistency of dominant components between ray-tracing and stochastic modeling in the 3GPP high-speed train scenarios. The results implies that the geometry near transmitter and receiver is the main influence of the dominant components. Thus, it makes sense to include ray-tracing into the standardized channel modeling approaches in order to keep spatial consistency of the channel and avoid the uncertainty of the reliability of the performance evaluation due to false stochasticity.

Study of Correlation and Power Imbalance on the MIMO Distributed System

J. Carlos González-Macias (Universidad de Extremadura, Spain); Juan Valenzuela-Valdés (Universidad de Granada, Spain); Pablo Padilla (University of Granada, Spain); Javier Carmona-Murillo (University of Extremadura, Spain)

This work is focused on achieving large performance gains in wireless networks by means of distributed or cooperative Multiple Input Multiple Output (MIMO) systems. In this contribution, it is studied in detail the correlation of different Cooperative MIMO Systems, based on measuring these systems on a reverberation chamber. Cooperative Systems with more than 10 antennas are studied in detail. These results show the impact of these new propagation channels on the 5th generation mobile communication systems, which will be of importance for the development and characterization of such systems. In this new systems power imbalance acquires more importance.

Channel Characterization Using Large Scale Uniform Arrays with Sidelobe Suppression

Fengchun Zhang, Wei Fan and Gert Pedersen (Aalborg University, Denmark)

A general form of Dolph-Chebyshev weighting methods is summarized for uniform linear arrays, uniform rectangular arrays and uniform cube arrays. In this paper, we adopt beamforming technique with both uniform amplitude weighting method and Dolph-Chebyshev amplitude weighting method to detect the channel multipaths. Numerical simulation results demonstrate the effectiveness of the sidelobe suppression techenique.

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Poster_07

Methods & Tools / Regular Session / Antennas

Room: Poster Sessions: Corridor Paris

Chairs: Ozlem Aydin Civi (Middle East Technical University, Turkey), Agnese Mazzinghi (University of Florence, Italy)

Adaptive Frequency Sampling for Radiation Patterns and S-parameters of Antennas

Ngoy Mutonkole (University of Stellenbosch, South Africa); Dirk de Villiers (Stellenbosch University, South Africa)

We present a fully automated method to predict the full radiation patterns and S-parameters of antennas over a

large frequency bandwidth using the knowledge of the simulated results at a few frequency points. The frequency points are adaptively selected in regions of fast variations of radiation pattern and S-parameters, as well as in large unsampled regions. The method has a built-in absolute error control measure and is guaranteed to converge to an accurate model in a modest number of iterations. The proposed method is validated through pertinent examples.

Field Quantities - a Geometrical Perspective

Ioan E. Lager (Delft University of Technology, The Netherlands)

Several geometrical modalities of representing electromagnetic (EM) field quantities are reviewed. The shortcomings arising from the representation as local vector functions are examined. Alternative geometrical frameworks that are capable to more accurately model the physics of the EM field are discussed. The study is intended to bring conceptual clarifications and to present incentives for including alternative perspectives within the scope of (basic) EM courses.

On the Fully Numerical Evaluation of Singular Integrals Over Coincident Quadrilateral Patches

Alexandra Tambova, Georgy Guryev and Athanasios Polimeridis (Skolkovo Institute of Science and Technology, Russia)

An extension to quadrilateral elements of the fully numerical method DIRECTFN, originally developed for the evaluation of 4-D singular integrals over triangular elements arising in Galerkin surface integral equation formulations, is presented. More specifically, a series of coordinate transformations together with integral re-orderings are applied in order to regularize the associate singular kernels in the case of coincident observation and source elements. The final expressions can be easily computed to machine precision by means of simple Gaussian quadrature rules, while the overall efficiency can be further improved by a judicious choice of the integration order of the resulting four 1-D integrals.

Analysis of Plasma-Based Devices with Coupled Surface-Volume Integral Equations and Characteristic Basis Functions

Davide Melazzi (University of Padova, Italy); Paola De Carlo (Department of Industrial Engineering, University of Padova, Italy); Marco Manente (T4I Srl, Italy); Vito Lancellotti (Eindhoven University of Technology, The Netherlands)

The interaction of electromagnetic waves and plasma has attracted attention as an important topic in plasma applications which encompass antennas and space propulsion systems. Regardless, the presence of metallic parts, e.g., antennas, and arbitrary-shaped, inhomogeneous, and magnetized plasma regions demands for a full-wave approach based on, e.g., the solution of surface-volume integral equations with the Method of Moments. Unfortunately, this approach may become impractical when the problem is so large as to be computationally expensive in terms of time and memory. To overcome this difficulty, we have extended surface-volume-integral-equation approach to include the decomposition of the computational domain and the definition of Characteristic Basis Functions. We give an overview on the strategy, we provide numerical analysis on the achieved computational savings. Besides, we apply the method to the analysis of plasma antennas, in which the plasma is represented by a complex permittivity with negative real part and large imaginary part.

First Experimental Characterization of a Gaseous Plasma Antenna in the UHF Band

Davide Melazzi (University of Padova, Italy); Paola De Carlo (Department of Industrial Engineering, University of Padova, Italy); Fabio Trezzolani (University of Padua, Italy); Vito Lancellotti (Eindhoven University of Technology, The Netherlands); Marco Manente, Daniele Pavarin, Francesco Rigobello and Antonio-D. Capobianco (University of Padova, Italy)

Gaseous plasma antennas are devices that exploit partially or fully ionized gas to transmit and receive electro-magnetic waves, in contrast with conventional antennas that are only made by metal and dielectric materials. Since plasma discharge parameters, e.g. plasma density, can be tuned, plasma antenna properties can be changed dynamically; this constitutes a promising alternative to conventional metallic antennas for applications in which reconfigurability is desired. In this work, we report on the first steps toward the realization, and the characterization in terms of radiation pattern, and magnitude of the reflection coefficient of an early prototype of a gaseous plasma antenna in the UHF frequency range. Numerical investigations have supported the design of the setup, and helped in the evaluation of the the role of plasma density profiles in affecting the antenna properties.

Page Spectrum as the New Tool for Linear Antennas Transient Analysis

Maciej Walkowiak (University of Science and Technology in Bydgoszcz, Poland); Anna Witenberg (UTP University of Science and Technology, Poland); Katarzyna Jagodzińska (Koszalin University of Technology, Poland)

The aim of this article is to present Page Spectrum as a tool to analyze transient phenomena in pulse-excited linear antennas. The Page spectrum transforms signal from the time domain into two-dimensional time-frequency domain. Page transform meets Parseval's theorem and does not generate false frequency components. Using Page transform allows to localize in time occurrence of oscillation components.

Efficient Computation of the Lattice Sums for Leaky Waves Using the Ewald Method

Paolo Baccarelli (Sapienza University of Rome, Italy); Vakhtang Jandieri (General and Theoretical Electrical Engineering (ATE), Faculty of Engineering, Germany); Guido Valerio (Sorbonne Universités UPMC, France); Giuseppe Schettini (Roma Tre University, Italy)

The efficient calculation of the Lattice Sums (LSs) for evaluating the free-space periodic Green's function (PGF) of an infinite phased array of line sources is addressed here and is extended for the first time to leaky waves. The method is based on the Graf's addition theorem for the 0-th order Hankel function that leads to an expansion in terms of Bessel functions of the relevant PGF. The coefficients of the expansion, called LSs, are slowly convergent series involving higher-order Hankel functions. Their efficient computation is performed by resorting to an extension of the standard Ewald method, in terms of spectral and spatial series having Gaussian convergence even in the case of complex waves and improper harmonics. The adopted approach allows for the analysis of a wide

class of periodic waveguides supporting leaky modes, and it is particularly suitable for the treatment of infinite array of dielectric fibers and rods.

Full-Wave Analysis of Leaky Modes in 2-D EBG Waveguides

Vakhtang Jandieri (General and Theoretical Electrical Engineering (ATE), Faculty of Engineering, Germany); Paolo Baccarelli (Sapienza University of Rome, Italy); Cristina Ponti and Giuseppe Schettini (Roma Tre University, Italy)

Full-wave numerical approaches for the analysis of leaky modes propagating in Electromagnetic-Bandgap (EBG) waveguides composed by multilayered arrays of two-dimensional (2D) cylindrical inclusions have been proposed. A first method based on the lattice sums technique for periodic structures with inclusions of circular section has been suitably adapted to the analysis of modes with complex propagation wavenumbers. The self-contained formulation uses a fast and accurate calculation of the lattice sums, which allows for an appropriate choice of the spectral determination for each spatial harmonic. A further full-wave modal method based on the Fourier Series Expansion in conjunction with perfectly matched layers (PMLs) has been developed, which can take into account cylindrical inclusions with arbitrary geometry of the transverse section. Real and imaginary parts of the propagation wavenumber are calculated with the two proposed approaches for a typical EBG waveguide and a very good agreement is observed in a wide frequency range.

Efficient and Accurate Simulation of Shielding Effectiveness in Coaxial Cables

Milos Pavlovic (WIPL-D DOO, Serbia); Branko Kolundzija (University of Belgrade, Serbia)

The subject of this paper is EM simulations of EMI field penetration into the coaxial cables. We investigate the three important mechanisms and the three levels of penetration: open ends, propagation through the solid outer shell wall with finite conductivity, and imperfections in the outer shell of the cable (small gaps in the braided wires). The induced power is compared in the three cases. When the shielding effectiveness is increased, the EM simulation gets more challenging, especially if high accuracy is required. Particularly, the model with braided shield is difficult to simulate for the extended cable length. An equivalency between the model with solid walls (and finite conductivity) and the model with strips replacing braided wires is established. The solid walls model is very efficient for simulation of very long cables (2 m cable at 10 GHz). The cable used as example is commonly used RG-58.

Performance Optimisation of Stencil-Based Codes for Shared Memory Architectures

Maksims Abalenkovs (The University of Manchester, United Kingdom)

The work presented in this publication proposes a novel view onto the standard form of Maxwell's equations in the FDTD method. The stencil-based equations are cast into a matrix form. Performance of the matrix casting is further improved by means of the OpenMP paradigm. Numerical results for both the sole FDTD and the FDTD with the Huygens Subgridding (HSG) are analysed.

The Fabrication and Test of Paraffin-based Dielectric Lenses for Metamaterial Characterization Using the Free-Space Method for 10-18 GHz

Reza Amiri and Behnam Zarghooni (INRS, University of Quebec, Canada); Javad Pourahmadazar (National Institute of Scientific Research (INRS), Canada); Tayeb A. Denidni (INRS-EMT, Canada)

In this study to show that the paraffin-based lens can handle high frequencies for metamaterial characterization, two dielectric lenses are fabricated using a molding process for the frequency range from 10 to 18 GHz. The fabricated lenses guarantee low cost and ease of implementation compared to the other machining and material methods. To verify the proposed lens performance, two similar paraffin lenses are used to measure the S-parameters of a conventional SRR metamaterial unit-cell. This experiment confirms a good agreement between simulation and measurement results.

Hardware Implementation of Directional Modulation System with a 2 Element Antenna Array

Saad Mufti (University of Sheffield, United Kingdom); Josep Parrón (Universitat Autònoma de Barcelona, Spain); Alan Tennant (University of Sheffield, United Kingdom)

A directional modulation system based on phase only modulation is demonstrated with a 2 element array. The hardware setup is discussed, and measurement results compared with simulations to analyze performance. We demonstrate how directional modulation offers greater security in directions other than intended, in contrast to conventional modulation.

High Impedance Surface for the Design of the Hankel Inward Leaky Wave Antenna

Ping Lu (École Centrale de Lyon, INSA de Lyon, Université Claude Bernard de Lyon & University of Electronic Science of Technology of China, France); Damien Voyer (Ecole centrale de Lyon); Arnaud Breard (Ecole Centrale Lyon, France); Julien Huillery (Ecole Centrale de Lyon & Laboratoire Ampère, France); Bruno Allard (INSA Lyon, France); Xue-Song Yang (University of Electronic Science and Technology of China, P.R. China)

A high impedance surface electromagnetic band gap (HIS-EBG) structure is proposed so as to design the core of a Hankel Inward Leaky Wave (HILW) antenna. HIS-EBG structure is expected to mimic a Perfect Magnetic Conductor (PMC), which is an alternative solution to the core absorber in order to generate properly the focusing spot with the HILW antenna. The proposed HIS-EBG structure is made of a mushroom-like structure that is dimensioned according to the 2-D dispersion diagram. The simulated electric field distribution with mushroom-like structure shows that the good focusing properties are close to the ones obtained in the PMC case, which agrees with the theoretical field distribution.

Dual-Band Lumped Element Decoupling Network Design for Two-Antenna Systems

Jaakko Juntunen (Optenni Ltd., Finland); Jussi Rahola (Optenni Ltd, Finland)

In this study we outline a design process for lumped element implementation of dual-band decoupling network for two coupled antennas. We justify by extensive numerical experimentation that the mutual admittance of the

antennas can be transformed to purely imaginary values at two given frequencies simultaneously by simple transmission line transformers at the antenna inputs. Our study shows that this conclusion is independent on the antennas under consideration, and applies to many different frequency band pairs. The decoupling is carried out by appropriate lumped element resonators that provide perfect reactive cancellation of the admittance at the center of each band. We propose practical optimization criteria for the decoupling network design that guarantee both a successful re-matching of the generally distorted impedance match, and a minimal influence of the matching network to the decoupling.

Design and Optimization of a 183 GHz Corrugated Horn for Humidity Sounder Using ANFIS

Jay Gupta (Institute of Technology, Nirma University, India); Dhaval Pujara and Dipak Adhyaru (Nirma University, India); Sanjeev Kulshrestha (Space Application Center, ISRO, India)

This paper presents the design and optimization of a 183 GHz profiled corrugated horn for a Microwave Humidity Sounder using Adaptive Neuro-Fuzzy Inference System (ANFIS). The theory and the process of designing antenna using ANFIS are discussed briefly. The return-loss and the radiation patterns of a horn, designed using ANFIS are compared with the results obtained using commercially available simulator and they were found in close agreement. It was observed that the horn can be designed using ANFIS based approach even with limited computational resources and very less processing time.

Accelerated Multi-Objective Design Optimization of Antennas by Surrogate Modeling and Domain Segmentation

Slawomir Koziel (Reykjavik University, Iceland); Adrian Bekasiewicz (Gdansk University of Technology, Poland); Qingsha Cheng (SUSTC, P.R. China); Song Li (University of Regina, Canada)

In this paper, a procedure for accelerated multi-objective design of antennas is proposed that exploits fast data-driven surrogates constructed at the level of coarse-discretization EM simulations, multi-objective evolutionary algorithm to yield an initial approximation of the Pareto set, and response correction methods for design refinement (i.e., elevating the selected Pareto-optimal designs to the high-fidelity EM simulation model level). To reduce the computational cost of setting up the surrogate, the relevant part of the design space is first identified through a series of single-objective optimization runs and subsequently represented by a set of adjacent compartments with separate surrogate models established within them. This segmentation process dramatically reduces the number of training samples necessary to build an accurate model thus limiting the overall optimization cost. Our approach is demonstrated using a UWB monopole antenna and compared to a state-of-the-art surrogate-assisted technique that does not use domain segmentation.

Sidelobe Reduction in Linear Antenna Arrays with Corporate-Feeds of Non-Uniform Power Distribution

Stanislav Ogurtsov and Slawomir Koziel (Reykjavik University, Iceland)

A systematic approach to sidelobe reduction of broadside linear antenna arrays using corporate feeds implementing non-uniform excitation is proposed. Only the corporate feeds that consist of equal-power split T-junctions, i.e., the simplest power dividers, are considered. First, for a given particular array aperture, candidate feeds are searched among excitation sets which might energize the aperture. The search is performed over all realizable excitations using the array factor and the model of excitation amplitudes due to power distribution within the feed. At the second stage, an excitation that provides reduced sidelobes and simple routing is implemented as a microstrip corporate feed. Finally, the entire antenna-feed circuit is tuned and validated using numerical optimization and discrete electromagnetic simulations at the high-fidelity level of description. Our approach offers flexibility in design of linear antenna arrays without introducing extra hardware complications. A case study of a twelve-element array-feed circuit explains and demonstrates our approach.

On Ultra-Wideband Antenna Miniaturization Involving Efficiency and Matching Constraints

Slawomir Koziel (Reykjavik University, Iceland); Adrian Bekasiewicz (Gdansk University of Technology, Poland); Qingsha Cheng (SUSTC, P.R. China); Song Li (University of Regina, Canada)

In this paper, size reduction of antenna structures taking reflection response and total efficiency into account has been investigated. In order to find available design trade-offs concerning the antenna footprint, its wideband matching, and efficiency, numerical optimization has been employed. Appropriate formulation of the objective function permits identification of the designs that exhibit the minimum possible footprint while maintaining the maximum in-band reflection and average efficiency within the prescribed thresholds. For the sake of demonstration, a specific case study of a UWB monopole is considered. A set of designs generated using the proposed approach provides a designer with a comprehensive knowledge about the capabilities of a given antenna topology and facilitates a decision making process driven by a particular application and performance requirements.

Simultaneous Generation of Near-Field Radiating Zone Vortex Modes by a RLSA Antenna

Agnese Mazzinghi and Angelo Freni (University of Florence, Italy)

The paper discusses the possibility of using a radial line slot array (RLSA) for simultaneously generating, in the microwave frequency band, several pseudo-Bessel beams having an azimuthal field variation characteristic of vortex modes. A specific application for non-contact microwave detection of buried objects has been considered as test case. The design benefits of Butler matrix network to provide the correct phase progression along the azimuthal coordinate, and it makes use of a holographic approach to assure the required aperture field distribution.

A Study on Variation of Side Lobe Level of Optimized Uniformly Excited Time-Modulated Linear Antenna Arrays

Sujit Kumar Mandal, Harshavardhan Singh and Ananya Mukherjee (National Institute of Technology, Durgapur, India); Kaushik Mandal (IRPE, CU, India)

In this paper, a study, regarding the variation of side lobe level (SLL) of 'optimized uniformly excited time-modulated linear antenna array' (OUE-TMLAA) with different number of antenna elements is presented. In order to realize OUE-TMLAAs, sideband levels (SBLs) is suppressed to -30 dB and the increase of first null beam width

(FNBW) is restricted within 35% of that of the 'uniformly excited conventional linear antenna arrays' (UE-CLAAs) while the peak is reduced as low as possible. A differential evolution (DE) based optimization method is employed where only the on-time sequence of the antenna elements are considered as the optimization parameter vectors. By taking the antenna arrays of wide range of number of antenna elements, starting from 10 to 500 and using the average results of 20 trials of each OUE-TMLAA, a representative plot of the variation of average SLLs with the number of antenna elements is presented.

Phase Error Analysis for Reflectarray Antennas Based on Study of Quasi-Periodic Effect

Tong Liu, Maokun Li, Fan Yang and Shenheng Xu (Tsinghua University, P.R. China)

Reflectarray antennas can be considered as quasi-periodic structures in which similar elements locate on periodic grids. In this paper, we compare the reflection phase of elements in the array between the designed value and the practical one. This error is mainly due to the assumption of periodicity in computing the designed element reflection phase. To study this error, we developed a method to obtain the reflection phase of a unit-cell in a practical reflectarray. On this basis, a workflow to decrease the phase error is developed and validated on a 665-element reflectarray antenna. Over 1dB increase on the antenna gain and 8 percent increase on aperture efficiency are observed.

GPU-based Parallel Algorithm for VPL-approximated EM Wave Propagation

Saki Matsuo, Masato Gocho, Takahiro Hashimoto and Atsuo Ozaki (Mitsubishi Electric Corporation, Japan)

The simulation of EM (electromagnetic) wave propagation requires considerable computation time, as it analyzes a large number of propagation paths. To overcome this problem, we propose a GPU (graphics processing unit)-based parallel algorithm for VPL (vertical plane launch)-approximated EM wave propagation. The conventional algorithm computes the gain along propagation paths with irregular memory access, which results in low GPU performance. In our proposed algorithm, a CPU reorders irregular propagation paths to a GPU-suitable linear order on the CPU memory at each receiving point. We hid the reordering time behind CPU-GPU communication and GPU-based computation of gain on the reordered memory. We found that our proposed algorithm with a quad GPU is up to 30 times faster than the conventional algorithm with a 16-threaded dual CPU.

An SDR Based Channel Sounding Technique for Embedded Systems

Hervé Boeglen (University of Poitiers XLIM Lab, France); Albekaye Traore and Manuel Milla (University of Poitiers, France); Romain Lefort (LABEX SIGMA_LIM); Rodolphe Vauzelle (XLIM, France)

This paper presents a low cost OFDM based channel sounding technique which can be implemented on a low power embedded system. The technique is first used to measure the channel of an indoor environment and is validated by comparison with a VNA and a ray-tracing simulator. We then show its usage in two interesting situations. Finally, we conclude the paper by giving the advantages and drawbacks of the technique and propose some solutions for improvement.

Study on the Optimal Matching Structure of the SMA Connector to a Microstrip Line

Zeng Liu-Xing, Lin Fu-Min, Zhang Yi-Song and Yang Hua-Ning (Guangdong University of Technology, P.R. China)

In this paper, the Minimum VSWR of the three kinds of conventional matching structures which the SMA coaxial connector connects to a microstrip line by inverted mode, upright mode or horizontal mode is studied. Modeling and structure optimization are carried out to pick out the optimal structure of the three kinds of matching structure by the simulation software HFSS. The results indicate that the horizontal matching structure is the best mode and the upright matching structure is the worst mode. The conclusion has certain reference value for the engineering application and the measurement of microwave devices, because many practical radio-frequency circuits has used SMA coaxial connectors of the upright matching structure as input/output ports.

HispaSim: a Web Application for Satellite Link Budget Optimization and Management

Luis Escolar Haro, Gregorio Juliana Quirós, Álvaro Rodríguez Villalba and Ramón Martínez Rodríguez-Osorio (Universidad Politécnica de Madrid, Spain)

Adequate link budget tools are required by satellite operators to generate optimized transmission plans that satisfies customer diverse demands using transponder resources (power and bandwidth) efficiently. Satellite operator has to face with a number of communication scenarios depending on the service. These scenarios cover from forward links used for DTH (Direct-to-Home) to bidirectional networks where both forward and returns can share the transponder resources. Moreover, a transition from desktop implementations to web-based applications is a must for satellite link budget tools. In this contribution, we present a web-based application entitled HispaSim conceived for the analysis and optimization of satellite link budgets that incorporates administration of users and database. HispaSim application has been developed by the Grupo de Radiación of ETSIT-UPM (Escuela Técnica Superior de Ingenieros de Telecomunicación, Universidad Politécnica de Madrid) developed for Hispasat and GMV.

Satellite Propagation Experiment in Ljubljana: Beacon Measurements at Ka- And Q-band

Andrej Vilhar and Arsim Kelmendi (Jozef Stefan Institute, Slovenia); Andrej Hrovat (Jožef Stefan Institute, Slovenia)

The paper gives a description of the satellite propagation measurement site established in Ljubljana. It consists of two beacon receivers, measuring the Alphasat and Astra 3B beacons at Ka-band and at Q-band, and of a co-located rain gauge. Statistical analysis of collected measurements is performed to create complementary cumulative distribution functions of excess attenuation and rain rate. First steps towards cross-polar discrimination analysis are presented. The results are discussed and compared to the corresponding ITU-R models.

Modular Transmitter and Receiver for Space-Time Coding

Quinten Van den Brande, Patrick Van Torre and Jo Verhaevert (Ghent University, Belgium); Jan Vanfleteren (Ghent University and IMEC, Belgium); Hendrik Rogier (Ghent University, Belgium)

In this article a MISO hardware design is reported, comprising both a transmitter and a receiver for space-time

coded signals. The transmitter implements Alamouti space-time coding, while the receiver uses maximum likelihood estimation to decode the space-time codes. As a result, the hardware communication system is configured as a 2x1 MISO link. The hardware is designed modularly, in order for the system to be easily extendible for the connection of multiple antennas. A digital core allows high-speed data generation in the signal generator units, forwarding analog I and Q signals to the radio-frequency modules connected to it. The BER performance of the Alamouti diversity scheme is compared to the performance of SISO and MRC systems. This comparison is based on simulation results, providing a good approximation of the theoretical BER performance, and a series of hardware measurements to empirically support this theoretical performance.

A Portable Compact Channel Sounder System Without Synchronization

Georg Zimmer, Alexander Weiß, Stefan Leis, Robert Geise and Björn Neubauer (Technische Universität Braunschweig, Germany)

In this contribution a vectorial channel sounding system for narrowband MISO applications is presented. The channel is measured using a continuous wave signal allowing the characterization of time-variant channels and Doppler shifts within changing multipath propagation environments. The channel sounder's architecture with an analog-digital converter writing the measured data to a SD-card enables measurements up to several minutes with a high frequency resolution. The compact, lightweight design allows the mounting of the channel sounder on a flying octocopter platform. A typical application is the investigation of multipath propagation for navigation systems in aviation by measurements in an environment scaled with the ratio of 1:144 at frequencies in the Ku-band. Without synchronization of the carrier frequencies of the transmitter and the receiver, high flexibility is achieved. This leads to high demands on the frequency stability of their reference clocks, discussed in the contribution along with the hardware setup.

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Poster_Awards

Future Applications / Regular Session / Antennas

Room: Poster Sessions: Corridor Top

Chairs: Francesco Andriulli (Ecole Nationale Superieure des Telecomunications de Bretagne, France), Dirk Manteuffel (University of Hannover, Germany)

Analysis of Artificial Dielectrics Composed of Non-Aligned Layers

Daniele Cavallo and Cantika Felita (Delft University of Technology, The Netherlands)

In this work, we present an analysis of artificial dielectric layers (ADLs), when a lateral shift between layers is present. The alternate lateral displacement of the layers is an important parameter to engineer the desired effective electromagnetic properties of the ADL material. More specifically, much higher equivalent dielectric constants can be realized by alternatively shifting the layers, compared to the aligned case. Closed-form expressions are given for the equivalent layer reactance that include the higher-order interaction between shifted layers. These analytical formulas are of great aid to design artificial dielectric slabs, as they provide the scattering parameters for generic plane-wave incidence. The effective permittivity and permeability tensors of the artificial dielectrics can then be retrieved from the scattering parameters.

Bianisotropic Huygens' Metasurface Leaky-Wave Antenna with Flexible Design Parameters

Elena Abdo-Sánchez (University of Málaga & E. T. S. I. Telecomunicación, Spain); Ariel Epstein (Technion - Israel Institute of Technology, Israel); George V. Eleftheriades (University of Toronto, Canada)

We propose a novel leaky-wave antenna configuration which consists of a parallel-plate waveguide with the top plate being a bianisotropic Huygens' metasurface of the omega type. By using closed-form expressions for the metasurface design and after a valid stipulation of the fields below and above it, we are able to design a passive and lossless metasurface that achieves the desired field transformation. The theoretical formulation highlights that we have practically all possible degrees of freedom in the stipulation of the input and output fields. In this way, several examples show that we can arbitrarily choose the output angle, the constant leakage factor and the waveguide height.

Emulating Arbitrary Antenna Arrays with Low-Profile Probe-Fed Cavity-Excited Omega-Bianisotropic Metasurface Antennas

Ariel Epstein (Technion - Israel Institute of Technology, Israel); George V. Eleftheriades (University of Toronto, Canada)

We present a methodology to design cavity-excited omega-bianisotropic metasurface (O-BMS) antennas capable of producing arbitrary radiation patterns, prescribed by antenna array theory. The method relies on previous work, in which we proved that utilizing the three O-BMS degrees of freedom, namely, electric and magnetic polarizabilities, and magnetoelectric coupling, any field transformation that obeys local power conservation can be implemented via passive lossless components. When the O-BMS acts as the top cover of a metallic cavity excited by a point source, this property allows optimization of the metasurface modal reflection coefficients to establish any desirable power profile on the aperture. Matching in this way the excitation profile to the target power profile corresponding to the desirable aperture fields allows emulation of arbitrary discrete antenna array radiation patterns. The resultant low-profile probed-fed cavity-excited O-BMS antennas offer a new means for meticulous pattern control, without requiring complex, expensive, and often lossy, feed networks.

Generation of Limited-Diffractive Twisted Pulses at Millimeter Waves

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Davide Comite (Sapienza University of Rome 1, Italy); Walter Fuscaldo (Sapienza University of Rome, Italy); Guido Valerio (Sorbonne Universités UPMC, France); Alessandro Galli (Sapienza University of Rome 1,

Italy); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Matteo Albani (University of Siena, Italy)

In this paper, the generation of twisted pulses carrying orbital angular momentum is discussed. Such pulses are generated by polychromatic superposition of higher-order Bessel beams. The non-negligible effect of the wavenumber frequency dispersion on the pulse propagation at millimeter waves is taken into account. Large operating bandwidths are required to synthesize spatially confined electromagnetic pulses. For this reason, a wideband Bessel-beam launcher is proposed, implementing an inward cylindrical traveling-wave aperture distribution with an azimuthal phase variation. Preliminary results clearly show the possibility of successful generation of twisted electromagnetic pulses at millimeter waves.

Wideband Analysis of RLSA Bessel Beam Launchers Based on Standing and Inward Traveling Wave Aperture Distributions for Electromagnetic Pulse Generation

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Agnese Mazzinghi and Angelo Freni (University of Florence, Italy); Matteo Albani (University of Siena, Italy)

In this paper, the dispersion properties of RLSA Bessel beam launchers, realized by enforcing both cylindrical standing wave and inward traveling wave aperture distributions, are compared. In particular, it is shown that such launchers can be profitably used for the generation of electromagnetic localized pulses at millimeter waves.

Demonstration of a High-Efficiency Reflectarray Antenna at 1 THz Based on Dielectric Resonators

Eduardo Carrasco (Foundation for Research on Information Technologies in Society, IT'IS, Switzerland); Daniel Headland (The University of Adelaide, Australia); Shruti Nirantar (RMIT University, Australia); Withawat Withayachumnankul (The University of Adelaide, Australia); Philipp Gutruf (Northwestern University & Rogers Research Group, USA); James Schwarz (RMIT University, Australia); Derek Abbott (The University of Adelaide, Australia); Madhu Bhaskaran and Sharath Sriram (RMIT University, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

A reflectarray antenna composed of more than 87000 single-crystal silicon resonators on a gold ground plane is experimentally demonstrated to achieve efficient beam focusing at 1 THz. The functionality of the reflectarray as a collimator is also verified by the principle of antenna reciprocity. Because of the low-loss and nondispersive nature of high-resistivity silicon in the submillimeter regime, the losses of the reflectarray are negligible, a very desirable feature at such frequencies. Reflectarrays based on dielectric resonator antennas (DRA) have been relatively unexplored in the terahertz range, mainly because of the challenging fabrication process.

Dielectric Ring Resonators as Chipless Temperature Sensors for Wireless Machine Tool Monitoring

Christian Mandel, Alejandro Jiménez-Sáez and Ersin Polat (Technische Universität Darmstadt, Germany); Martin Schüßler (TU Darmstadt, Germany); Bernd Kubina, Timo Scherer and Nils Lautenschläger (Technische Universität Darmstadt, Germany); Rolf Jakoby (Institute for Microwave Engineering and Photonics, Technische Universität Darmstadt, Germany)

Temperature monitoring of tools is one key method for the prediction and detection of tool failure to prevent damage of valuable workpieces, e. g. in aircraft manufacturing. Therefore, a chipless wireless dielectric temperature sensor for machine tools, with very high temperature capability and compatibility to the harsh machine tool environment, is investigated. Based on these findings, a demonstrator is introduced that is characterized in the lab and tested in a real machine tool. The paper focuses on real world challenges of the sensor system implementation.

Modulated Tensorial Metasurfaces for Aperture Field Generation

Mounir Teniou (Sorbonne Universités & L2E, France); Hélène Roussel (Sorbonne Université UPMC Paris 06, France); Nicolas Capet (CNES, France); Gerard Pascal Piau (Airbus Group Innovations, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France)

This paper presents a procedure for generating radiating aperture fields using tensorial metasurfaces. The aperture field is generated using surface wave to leaky wave conversion resulting from metasurface modulation. Amplitude and phase control are achieved using varying modulation parameters and holography principle respectively. In order to validate the design procedure, a numerical solution is presented for a multi-beam metasurface antenna working at 20GHz.

Recent Work on (sub-)mm-wave Ultra WideBand Corrugated Horns for Radio Astronomy

Alvaro Gonzalez and Keiko Kaneko (National Astronomical Observatory of Japan, Japan); Shin'Ichiro Asayama (National Astronomical Observatory of Japan, Chile)

Corrugated horns are widely used in many applications, including radio astronomy, because of their high performance over large bandwidths. However, the always increasing demand for wider frequency coverage cannot be met by traditional conical corrugated horns with typical fabrication constraints at (sub-)mm wavelengths. The usual way to overcome this limitation is to use profiled corrugated horns, such as the 275-500 GHz horn presented in this paper. As an alternative, we propose and demonstrate that conical corrugated horns can achieve ultra-wideband (UWB) performance by changing the depth of corrugations along the horn. A design for the 67-116 GHz band is presented. Fabrication of these two designs is on-going and measurements will be presented at the conference.

Shared Aperture Metasurface Antennas for Multibeam Patterns

David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Gabriele Minatti and Enrica Martini (University of Siena, Italy); Goutam Chattopadhyay (JPL, USA); Stefano Maci (University of Siena, Italy)

This paper describes various possibilities for designing multibeam antennas using a single metasurface (MTS) aperture. Both single-source and multi-source feeding schemes are considered. For the single-source case, two approaches are investigated: i) division of the aperture in several angular sectors (one per beam) and ii) superposition of the individual modulations required to obtain the beams in the desired directions. A configuration based on a multi-source feeding scheme is also tailored by a superposition of modulation patterns. Numerical results based on the Method of Moments are presented for validation.

Design and Calibration of a Double-directional 60 GHz Channel Sounder for Multipath Component Tracking

Ruoyu Sun (National Institute of Standards and Technology, USA); Peter Papazian and Jelena Senic (NIST, USA); Yeh Lo (NTIA, USA); Jae-Kark Choi (National Institute of Standards and Technology, USA); Kate A. Remley and Camillo Gentile (NIST, USA)

The 60 GHz band is being considered for many high-bandwidth wireless applications. To support standards development for these applications, NIST has developed an untethered 60 GHz, 8×16 MIMO channel sounder. It employs a pseudorandom bit sequence with a bandwidth of 4 GHz. The sounder can precisely measure radio propagation channel characteristics such as path loss, small-scale fading, delay dispersion, absolute delay, angle-of-arrival (AoA), angle-of-departure (AoD), and Doppler power spectrum. Its ability to measure the time dynamics of the millimeter-wave radio channel, when untethered and in motion, is unique. It employs electronically-switched MIMO antenna arrays, a robot for moving measurements and an automated one-dimensional positioner for precision measurements at fixed locations. Sounder performance is improved by use of pre-distortion filters and precision calibration of the RF and timing systems. Data showing initial AoD and AoA estimation error are presented along with initial test results for ground-plane reflection.

Examination of the Effectiveness of Far-field Mathematical Absorber Reflection Suppression in a CATR Through Computational Electromagnetic Simulation

Stuart Gregson (NSI-MI & Queen Mary, University of London, USA); Clive Parini (QMUL, United Kingdom); Allen Newell and Greg Hindman (Nearfield Systems Inc., USA)

For a little over a decade, a measurement and post-processing technique named Mathematical Absorber Reflection Suppression (MARS) has been used successfully to identify and then suppress range multi-path effects in spherical, cylindrical & planar near-field antenna measurement systems and far-field and compact antenna test ranges (CATR). Much of this early work concentrated on verification by empirical testing however some corroboration was obtained with the use of computational electromagnetic simulations. The recent development of a highly accurate computational electromagnetic simulation tool that permits the simulation of "measured" far-field pattern data as obtained from using CATR has for the first time permitted the careful verification of the far-field MARS technique for a given AUT and CATR combination. For the first time, this paper presents simulated "measured" far-field pattern data in the presence of a large scatterer and then verifies the successful extraction of the scattering artefacts using standard FF-MARS processing.

Inverse-Source Algorithm for Antenna-Field Transformations Using the Weak Form of the Combined-Source Condition

Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany); Thorkild Birk Hansen (Seknion, Inc., USA)

Inverse equivalent-source algorithms for antenna field transformations are particularly powerful and robust if they work with directive sources that radiate primarily from the source region towards the field observation locations. Such directive behaviour can for example be achieved by employing an additional integral equation that explicitly imposes a null-field condition (known also as a Love condition) in the original source region of the antenna. An approximate null-field condition can be achieved in the form of an impedance-boundary condition, which is also known as the combined-source condition. In this work, the combined-source condition is utilized in a weak form, and the directivity of the expansion sources is further increased by shifting the source points into complex space. This inverse source algorithm is formulated and used for near-field to farfield transformations of measured antenna fields. The results are discussed and compared to those achieved with the corresponding strong-form algorithm.

Spectral Polarimetric Features Analysis of Wind Turbine Clutter in Weather Radar

Jiapeng Yin, Oleg Krasnov and Christine Unal (Delft University of Technology, The Netherlands); Stefano Medagli (TU Delft & Thales, The Netherlands); Herman Russchenberg (Delft University of Technology, The Netherlands)

Wind turbine clutter has gradually become a concern for the radar community for its increasing size and quantity worldwide. Based on the S-band polarimetric Doppler PARSAX radar measurements, this paper demonstrates the micro-Doppler features and spectral-polarimetric characteristic of wind turbine clutter, the probability distribution functions of different spectral-polarimetric variables. Finally, a simple thresholding method to remove wind turbine clutter is put forward, and its effectiveness can be verified by the measured data. This work is expected to contribute to developing effective algorithms for this dynamic clutter suppression for operational weather radar.

Wide Band Propagation in Train-to-Train Scenarios - Measurement Campaign and First Results

Paul Unterhuber and Stephan Sand (German Aerospace Center (DLR), Germany); Mohammad Soliman (Deutsches Zentrum für Luft- und Raumfahrt, Germany); Benjamin Siebler (DLR-German Aerospace Center, Germany); Andreas Lehner (German Aerospace Center (DLR) & Intelligence on Wheels, Germany); Thomas Strang (German Aerospace Center (DLR) & University of Innsbruck, Intelligence on Wheels, Germany); Maurizio d'Atri and Fabrizio Tavano (Trenitalia S.p.A., Italy); Damini Gera (Technische Universität Ilmenau, Germany)

Within the next decades the railways will change to fully autonomous high speed trains. An increase in efficiency and safety and cost reductions would go hand in hand. Today's centralized railway management system and established regulations can not cope with trains driving within the absolute braking distance as it would be necessary for electronic coupling or platooning maneuvers. Hence, to ensure safety and reliability, new applications

and changes in the train-control and -management are necessary. Such changes demand new reliable communication links between train-to-train (T2T) and future developments on train-to-ground (T2G). T2G will be covered by LTE-R which shall replace today's GSM-R. The decentralized T2T communication is hardly investigated and no technology has been selected. This publication focuses on the wide band propagation for T2T and describes a extensive channel sounding measurement campaign with two HSTs. First results of T2T communication at high speed conditions in different environments are presented.

A Comparison of Indoor Channel Properties in V and E Bands

Aliou Bamba (CEA-LETI & Université Grenoble-Alpes, France); Francesco Mani (Università degli studi di Bologna, Italy); Raffaele D'Errico (CEA, LETI, Minatec Campus & Univ\. Grenoble-Alpes, France)

This paper presents wideband channel measurements in an office environment in the 62 GHz and 83 GHz frequency bands. Measurements were performed with a VNA and the mechanical steering of directive antennas at both the transmitter and receiver side, allowing a double-directional angular characterization. A comparison of propagation characteristics such as the path loss, multipaths clusters' dispersion properties in the delay and angular domains are provided. Results show that similar propagation characteristics are attainable in the two bands considered.

A Compressive Sensing Unmixing Algorithm for Breast Cancer Detection

Jose Martinez Lorenzo and Richard Obermeier (Northeastern University, USA)

In this paper, we describe a novel unmixing algorithm for detecting breast cancer. In this approach, the breast tissue is separated into three components, low water content (LWC), high water content (HWC), and cancerous tissues, and the goal of the optimization procedure is to recover the mixture proportions for each component. By utilizing this approach in a hybrid DBT / NRI system, the unmixing reconstruction process can be posed as a sparse recovery problem, such that compressive sensing (CS) techniques can be employed. A numerical analysis is performed, which demonstrates that cancerous lesions can be detected from their mixture proportion under the appropriate conditions.

Evaluation of Array Antenna Systems for GNSS Applications Using Wave-Field Synthesis in an OTA Laboratory

Christopher Schirmer (Technische Universität Ilmenau, Germany); Alexander Rügamer (Fraunhofer IIS, Germany); Wim A. Th. Kotterman (Technische Universität Ilmenau, Germany); Markus Landmann (Fraunhofer Institute for Integrated Circuits IIS, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany)

Antenna characterization is usually performed by antenna pattern measurements in an anechoic chamber. Subsequently, a conducted test, the Radiated Two-Stage (RTS) or the Wireless-Cable method can be used for an overall system test considering the measured patterns. In this paper we present a method to perform device tests for antenna arrays / smart antennas without the need of radiation pattern measurements, and we validate it experimentally. By using Over-The-Air tests in a Virtual Electromagnetic Environment and Wave-Field Synthesis, the propagation environment can be realistically recreated in the region around a Device-Under-Test. This allows for reproducible performance comparisons of different antennas or systems under identical propagation environment conditions. As a special application, we consider the Controlled Reception Pattern Antenna (CRPA) in a Global Navigation Satellite Systems environment in the presence of interferer signals.

Investigations on Fading Scaling with Bandwidth and Directivity at 60 GHz

Diego Dupleich (Ilmenau University of Technology, Germany); Naveed Iqbal (Huawei Technologies, Germany); Christian Schneider (Ilmenau University of Technology, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Robert Müller and Sergii Skoblikov (TU Ilmenau, Germany); Jian Luo (Huawei Technologies Duesseldorf GmbH, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany)

In the present paper we analyse small-scale fading of reflections at 60 GHz using different antennas and bandwidths. The aim is to investigate the deterministic property of the channel in view of modelling and deployment of systems with larger bandwidths and higher directivity. We have investigated the scattering effect of a reflection on a wall emulating a beam-former in a NLOS condition. The results show that the distribution of the amplitudes fit better with a Rician than a Rayleigh distribution. Furthermore, we show that an increasing bandwidth and directivity increases the K-factor, supporting the idea of deterministic paths apart from the LOS.

TDOA-Based Microwave Imaging Algorithm for Real-Time Monitoring of Microwave Ablation

Shouhei Kidera (University of Electro-Communications, Japan); Luz Maria Neira, Barry Van Veen and Susan Hagness (University of Wisconsin-Madison, USA)

Microwave ablation (MWA) is widely recognized as a promising treatment tool for cancer. To ensure an effective and safe treatment, real-time monitoring of the dimensions of the ablation zone is indispensable. In this paper, we propose a microwave imaging algorithm for monitoring the evolution of the ablation zone. This algorithm estimates the boundary of the ablation zone by exploiting the time difference of arrival (TDOA) between pre- and during-ablation signals. A notable advantage of this method is that it requires few assumptions about the spatial distribution of dielectric properties of the propagation media. We investigate the performance of this approach using simulated array measurements obtained from FDTD simulations of MRI-derived numerical breast phantoms. The results demonstrate that our proposed method offers the potential to achieve millimeter order accuracy in estimating the boundary of the ablation zone in heterogeneous and dispersive breast tissue.

A Compact Satellite Antenna Module for GPS, Galileo, GLONASS, BeiDou and SDARS in Automotive Application

Iuliia Goncharova (University of the Bundeswehr, Munich, Germany); Stefan Lindenmeier (Universität der Bundeswehr, Germany)

A new design concept of a compact satellite antenna module for automotive application is presented, enabling mobile reception of all common navigation systems, e.g. GPS in L1&L2 bands, Galileo, GLONASS, BeiDou, as well as reception of satellite digital audio radio service (SDARS). A new design concept allows easy fabrication in combination with high reception properties. The performance of the antenna module, fulfilment of the requirements of car manufacturers and service providers is proven by simulated and measured results, showing the high realized gain for circular polarization, efficiency, matching and decoupling against terrestrial interferers.

A Dielectric Lens Antenna Fed by a Flexible Dielectric Waveguide At 160GHz

Martin Geiger and Martin Hitzler (University of Ulm, Germany); Johannes Iberle (Ulm University of Applied Sciences, Germany); Christian Waldschmidt (University of Ulm, Germany)

Flexible antennas in radar applications enable the user to go around obstacles or detect targets at hidden places. In this paper, two elliptical lenses of different size made of high density polyethylene and stacked on a flexible dielectric waveguide are designed and measured from 140 GHz to 180 GHz. The feeding dielectric waveguide and the mode transition from metallic waveguide to dielectric waveguide was investigated with full wave simulations. The elliptical lenses were designed with a geometrical optics approach. The realized antennas have a gain larger than 24 dBi and 27 dBi and a maximum side lobe level below −15.8 dB.

Long Reading Range Chipless RFID System Based on Reflectarray Antennas

Maher Khaliel (Universität Duisburg-Essen, Germany); Ahmed Elawamry (University of Duisburg-Essen, Germany); Abdelfattah Fawky (University of Duisburg Essen, Germany); Thomas Kaiser (Universität Duisburg-Essen, Germany)

This work proposes the utilization of the Reflect Array (RA) antenna in the reader of the Frequency Coded (FC) chipless RFID systems aiming at increasing the reading range, minimizing the environmental reflections and acquiring a lot of novel capabilities that can not be provided by the conventional antenna systems. The presented RA antenna operates over UWB range of frequencies from 4 to 6 GHz fulfilling the requirements of the FC chipless RFID systems. Furthermore, the RA antenna beam is 4 times narrower than the feeder beam and thus 6 dB higher in gain with -10 dB SLL. Therefore, this developed UWB RA antenna is successfully integrated with the FC chipless RFID tags and a reading range of 1 m is attained. To the best of the author knowledge, this is the highest reading range achieved in the FC chipless RFID systems, considering real-world indoor environment and software defined radio reader.

Multi-frequency Power Angular Spectrum Comparison for an Indoor Environment

Usman Tahir Virk, Sinh Nguyen and Katsuyuki Haneda (Aalto University, Finland)

This paper presents the comparison of power angular spectra at frequencies below and above 6 GHz, i.e., 2, 15, 28, 60 GHz. With the increased focus on millimeter wave frequencies for ultra-high data rates, a detailed understanding of channel frequency dependence has become crucial. The analysis in this paper is based on multi-frequency radio channel measurements in an indoor coffee room environment for both line-of-sight (LOS) and non-LOS scenarios. For multipath extraction, two different methodologies are used at below and above 6 GHz frequency bands, respectively. The results indicate that LOS channels demonstrate a similar spatial spread at all the frequencies considered, and hence can be spatially modeled in a similar fashion. The NLOS channels exhibit larger spatial spread overall. The paths at above 6 GHz channels appear to be spatially more consistent compared to those that are below 6 GHz, where penetrated and the diffracted paths also exist.

Wireless Monitoring of Breath by Means of a Graphene Oxide-based Radiofrequency Identification Wearable Sensor

Maria Cristina Caccami and Mohammad Yusuf Shafi Mulla (University of Rome "Tor Vergata", Italy); Corrado Di Natale (Università di Roma Tor Vergata, Italy); Gaetano Marrocco (University of Rome "Tor Vergata", Italy)

The monitoring of the breathing dynamic characteristics, including the presence of biomarkers in exhaled breath, is of growing interest in noninvasive diagnosis of diseases. We describe a wearable radiofrequency identification (RFID) device hosting a flexible antenna suitable for integration into a facemask and a sensor made of graphene oxide sensitive to the humidity variations. The so obtained wearable wireless sensor was characterized in reference conditions and was then experimentally demonstrated to be capable of detecting the inhalation/exhalation cycles and abnormal patterns of respiration like the apnea by measuring the changes in graphene oxide resistance.

Thursday, March 23, 13:30 - 16:20

SWS_04: Radiofrequency coils for Magnetic Resonance Imaging

TOP

WG Meetings & Workshops: Room 313/314

Chairs: Redha Abdeddaim (Aix Marseille University, France), Stanislav Glybovski (ITMO University, Russia)

SWS_02_I: Frontiers in Propagation and Wireless Channel Modeling

TOP

WG Meetings & WorkShops: Room 315

Chair: David W Matolak (University of South Carolina, USA)

Thursday, March 23, 15:00 - 16:20

Inv_05 Invited Session 5

TOP

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Raj Mittra (Penn State University, USA), Ala Sharaiha (Université de Rennes 1 & IETR, France)

15:00 ***Antenna Current Optimization and Optimal Design for Small Antennas***

Mats Gustafsson (Lund University, Sweden)

Antenna design can be considered as an art of shaping and choosing materials to produce a desired current distribution on the antenna structure. Antenna current optimization is a tool to determine an optimal current distribution which can be used for physical understanding, as a priori estimates of the possibilities to design antennas, physical bounds, and as figures of merits for antenna designs. Antenna current optimization is particularly useful for small antennas for which the Q-factor and stored energy are of primary importance. In this presentation, antenna current optimization and stored electromagnetic energy expressions are reviewed. A tutorial description of the steps used to determine the lower bounds on the Q-factor for arbitrarily shaped structures and structures embedded in metallic structures are presented. Moreover, it is demonstrated how the approach can be modified to handle lossy and dispersive materials as well as antenna quantities such as efficiency, gain, directivity, and capacity.

15:40 ***Transmission Equations for Single and Multiple Antenna Systems - From Basic Formulations to Antenna Measurements in Complex Environments***

Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

Under far-field conditions, the transmission of electromagnetic waves is commonly described by the Friis transmission equation. Wave propagation effects can be included by ray concepts together with appropriate phase terms. Motivated by the needs of near-field antenna measurements, we will look into a couple of near-field antenna transmission equations, where we will find that spectral formulations of such transmission equations are commonly advantageous in terms of physical insight and numerical treatment. A very flexible and numerically advantageous near-field transmission equation works with spectral propagating plane wave representations and it is found that this equation is nothing else than a near-field generalization of the Friis transmission equation. Based on this transmission equation, we will formulate antenna field transformation algorithms and we will show the performance of such algorithms for field transformations in complex environments, where reflection and scattering effects are involved or where only near-field measurements without phase information are available.

Inv_06 Invited Session 6

TOP

Room: Oral Sessions: Auditorium Havane

Chairs: Dirk Heberling (RWTH Aachen University, Germany), John Sahalos (Aristotle University of Thessaloniki, GR, Thessaloniki & University of Nicosia, CY, Nicosia, Greece)

15:00 ***On-body Antennas for Critical Bio-Signal Monitoring Systems***

Jaehoon Choi (Hanyang University, Korea)

In this invited talk, three types of on-body antennas for bio-signal monitoring systems will be presented. Firstly, antenna design techniques for on-body to on-body communications are discussed; (1) TM21 higher order mode patch antenna with monopole-like radiation; (2) additional corrugation/EBG structure for body surface wave enhancement. Secondly, designs of dual-modes antennas for repeater systems are introduced. In order to design dual-modes antennas for in-on-on and on-on-off communication links, we propose a few miniaturization techiques as well as how to integrate two radiating elements with different operating frequencies into a single antenna structure. Lastly, the textile antenna using all-textile materials such as conductive textile, conductive thread, and non-conductive fabric for practical wearable applications is presented.

15:40 ***A Special Antenna Gain Measurement Technique***

Chi-Chih Chen (The Ohio State University, USA)

Conventional antenna gain measurement techniques involve transmission measurements of additional antennas in addition to antenna under test. This not only increases the amount of measurements but also introduce error associated with setup changes and reference gain accuracy. The scattering and unbalanced current radiation from the cable can sometimes introduce measurement error. Furthermore, the cable loss associated with the long cable below VHF and above Ku band becomes a major limitation factor in measurement sensitivity. This talk discusses an alternative antenna gain measurement technique based on backscattering measurement of the antenna. This approach completely eliminates the cable connected to the antenna and reference gain antenna. The methodology and simulation examples will be demonstrated. The accuracy and limitations of this method will also be discussed. This gain measurement could be very useful for determining gain patterns of antenna in situ such as antenna on chip, wearable antennas, and antenna on wafer.

Thursday, March 23, 16:50 - 18:30

Sp_A04 MetaSurfaces for Space Applications

Space / Regular Session / Antennas
Room: Oral Sessions: Auditorium Bordeaux
Chairs: Hervé Aubert (Laboratory of Analysis and Architecture of Systems & Institut National Polytechnique de Toulouse, France), Goutam Chattopadhyay (JPL, USA)

16:50 ***3D Printed Gradient Index Dielectric Metasurface for Beam Steering Applications***
Badreddine Ratni (Institut d'Electronique Fondamentale, France); André de Lustrac (Institut d'Electronique Fondamentale - Université Paris-Sud, France); Gerard-Pascal Piau (EADS CCR, France); Shah Nawaz Burokur (LEME, France)
A gradient index dielectric metasurface composed of air holes of different dimensions in a bulk dielectric, is fabricated by three-dimensional (3D) polyjet printing and is combined with inductive and capacitive copper grids to have an LC resonance. The latter metal-dielectric metasurface is then used as a phase-gradient superstrate in a Fabry-Perot cavity at microwave frequencies. Performed simulations and measurements show good performances in steering the emitted radiated beam to an off-normal direction.

17:10 ***Modulated Tensorial Metasurfaces for Aperture Field Generation***
Mounir Teniou (Sorbonne Universités & L2E, France); Hélène Roussel (Sorbonne Université UPMC Paris 06, France); Nicolas Capet (CNES, France); Gerard Pascal Piau (Airbus Group Innovations, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France)
This paper presents a procedure for generating radiating aperture fields using tensorial metasurfaces. The aperture field is generated using surface wave to leaky wave conversion resulting from metasurface modulation. Amplitude and phase control are achieved using varying modulation parameters and holography principle respectively. In order to validate the design procedure, a numerical solution is presented for a multi-beam metasurface antenna working at 20GHz.

17:30 ***Characterization of a Dual Band Metasurface Antenna with Broadside and Isoflux Circularly Polarized Radiation Patterns***
Amagoia Tellechea (Public University of Navarra, Spain); JuanCarlos Iriarte (Public University of Navarra & Antenna Group, Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain); Ramon Gonzalo (Public University of Navarra, Spain); Enrica Martini and Stefano Maci (University of Siena, Italy)
In this paper, we present the theoretical considerations for the implementation of a single layer anisotropic metasurface (MTS) antenna capable to provide different circularly polarized radiation patterns at two frequencies at Ku band (13.5GHz and 16GHz). Circular metallic subwavelength patches with a groove through the diameter are employed to synthesize the proposed MTS configuration. At lower band broadside radiation with a maximum directivity of 26.5dBs is obtained, with 28dBs cross polar field component. At higher band, isoflux-shaped radiation pattern with a drop-off angle around 33 degrees and 10dBs cross polar field is obtained.

17:50 ***Low Cross Polarization Conical MetaHorn Based on an Adiabatic Mode Formulation***
Valentina Sozio (Istituto Superiore Mario Boella, Italy); Marco Faenzi (University of Siena, Italy); Matteo Alessandro Francavilla (Istituto Superiore Mario Boella, Italy); Enrica Martini and Francesco Caminita (University of Siena, Italy); Marco Sabbadini (Esa Estec, The Netherlands); Stefano Maci (University of Siena, Italy); Giuseppe Vecchi (Politecnico di Torino, Italy)
This paper presents a modal field-based approach for an initial design of low cross hybrid mode conical horns with engineered metasurfaces (MTSs) as sidewalls, described through equivalent surface impedances, referred to as MetaHorns (MTHs). The proposed method overcomes the intrinsic non-separability problem in conical structures with arbitrary walls through an adiabatic local mode approximation. By exploiting the fundamental mode adiabatic propagation characteristics as input for MTS design, the approach provides a good starting point for the design of MTHs with symmetric radiation pattern and low cross polarization. The quasi-analytical nature of the method assures a physical insight on MetaHorn behavior, resulting in a better control on design process, lightning optimization algorithms and full wave simulations, which can be thus used in a subsequent step as refinement of the antenna synthesis process.

18:10 ***Design, Fabrication and Testing of a Modulated Metasurface Antenna at 300 GHz***
David González-Ovejero (Centre National de la Recherche Scientifique - CNRS, France); Cecile Jung-Kubiak (NASA-JPL, Caltech, USA); Maria Alonso-delPino (Jet Propulsion Laboratory, USA); Theodore Reck (NASA-JPL, Caltech, USA); Goutam Chattopadhyay (JPL, USA)
This paper describes the design and realization of a modulated metasurface (MTS) antenna at 300 GHz. To overcome the hurdles associated with the use of dielectric substrates in the sub-millimeter wave range, we propose an MTS structure which consists of an array of metalized cylinders placed on a ground plane. The metal cylinders are arranged in a square lattice with sub-wavelength unit cell size. This MTS topology has been successfully used to design a spiral MTS antenna. The resulting structure has been micromachined out of a silicon wafer by means of deep reactive ion etching (DRIE). The performance of the antenna has been verified by full-wave simulations, and measurements will be available at the time of the conference.

CS14 Electronically Scanned SatCom Terminal Antennas: State-of-the-Art and New Developments

TOP

Space / Convened Session / Antennas
Room: Oral Sessions: Auditorium Havane
Chairs: Stefania Monni (TNO Defence Security and Safety, The Netherlands), Maria Carolina Vigano (Viasat Antenna Systems SA, Switzerland)

16:50 ***A Modular AESA Panel Array for SatCom Applications***

Alexander Müller (Airbus Defence and Space, Germany); Patrick Schuh, Sebastien Chartier and Bernhard Schweizer (Airbus DS Electronics and Border Security, Germany)

A scalable AESA panel array for Ka-band SatCom applied to moving platforms has been developed and tested. The AESA is capable of 2D electronically scanning. One main aspect of the concept and design was to keep the production costs low. This is especially necessary for commercial products. One advantage of the realized modular concept is the scalability to adapt the product to different data rates. Due to the integrated cooling structure and the optimized electrical efficiency very compact liquid cooling solutions or even air cooling is possible and can be adapted to the platform needs or restrictions.

17:10 ***DragOnFly - Electronically Steerable Low Drag Aeronautical Antenna***

Fabrizio Silvestri (Eindhoven University of Technology & Nederlandse Organisatie voor Toegepast- Natuurwetenschappelijk Onderzoek TNO, The Netherlands); Alice Benini (University of Siena, Italy); Erio Gandini (Delft University of Technology, The Netherlands); Giampiero Gerini (TNO - Defence, Security and Safety, The Netherlands); Enrica Martini and Stefano Maci (University of Siena, Italy); Maria Carolina Vigano (Viasat Antenna Systems SA, Switzerland); Marcel Geurts (NXP Semiconductors, The Netherlands); Giovanni Toso (European Space Agency, The Netherlands); Stefania Monni (TNO Defence Security and Safety, The Netherlands)

This paper presents design considerations for the development of wide-scanning antennas for on-craft satellite communications. A scanning coverage of 80^{0} is required over a 15% bandwidth in Ka-band. A solution based on a phased array illuminating a passive superstrate is identified as the most promising. A fully-electronic beam-scanning is considered to reduce the overall thickness of the antenna architecture by avoiding mechanical rotational supports. This is beneficial since a reduced thickness corresponds to a lower drag. Two kinds of superstrates were investigated, a flat solution and a flattened dome. In both cases, the deflecting structure is illuminated by a phased array and is represented as a surface characterized by a phase shift distribution that allows to maintain high gain up to very large scan angles. A flatter gain profile compared to a typical cosine scan loss for planar phased arrays was achieved in both cases.

17:30 ***Liquid Crystal Based Beam Scanning Reflectarrays and Their Potential in SATCOM Antennas***

Gerardo Perez-Palomino (Universidad Politécnica de Madrid, Spain); Mariano Barba and Jose A. Encinar (Universidad Politecnica de Madrid, Spain); Robert Cahill and Raymond Dickie (Queens University Belfast, United Kingdom); Paul Baine (Queen's University of Belfast, United Kingdom)

This paper presents recent developments in Liquid Crystal-based reflectarray antennas for mm-wave applications, future perspectives for this technology and its particular use in SATCOM applications

17:50 ***Quad Band X/Ka Horn Antenna and Feed Chain Designs***

Jorge Teniente (Public University of Navarra & Institute of Smart Cities, Spain); Iker Gómez-López and Ruben Caballero-Nagore (Public University of Navarra, Spain); Gonzalo Crespo (Anteral, Spain); Aitor Martinez (ANTERAL, Spain)

This paper proposes the performance comparison of two different corrugated feedhorns and their corresponding feed chains working simultaneously in the X and Ka frequency bands. One of the solutions is composed of an X band coaxial corrugated horn that combines axial and radial corrugations fed laterally by an OMTJ formed by four branches to allow dual polarization and a smooth-walled spline-profile Ka band horn antenna placed inside the inner coaxial of the corrugated X band horn. The second solution is formed of a radial corrugated horn antenna for Ka band connected directly to another horn antenna that combines axial and radial corrugations for X band. The X band horn antenna part is also fed by an OMTJ formed by four branches. Both results which have been optimized for a science mission communication satellite specification requirement are very compact, allowing dual polarization and combining both frequency bands in the same profile.

18:10 ***Squinted Elevation Antenna for Ku Band DVB Satellite Reception with Electronically Steered Azimuth***

Neil Buchanan (Queens University Belfast, United Kingdom); Vincent Fusco (Queen's University Belfast, United Kingdom); Arpan Pal (Swansea University, United Kingdom)

This paper describes a Ku band, electronic beam steered array, operating at 10.7 GHz to 12.7 GHz intended for satellite DVB reception. The beam steering operates in the azimuth plane and the antenna also has a fixed beam squint at 23 deg elevation. This allows the antenna to be mounted vertically on a wall. Therefore the mounting can be very discrete, with less than 1cm protrusion from a wall in comparison to much bulkier parabolic dish antenna solutions. The relative simplicity and low profile of the antenna has been made possible by the use of COTS Ku band IC's, combined with novel analogue IF beamforming circuits. The antenna has been shown to be capable of receiving commercial DVB satellite signals transmitted from the Astra satellite in the UK. The antenna has dimensions of 25x37cm and is less than 1cm thick. It has a measured G/T of 7dB/K

W_A03 3D Printed Antennas

Wireless Networks / Regular Session / Antennas
Oral Sessions: Room 341
Chairs: Darren Cadman (Loughborough University, United Kingdom), Alexandros I. Dimitriadis (Ecole Polytechnique Fédérale de Lausanne & SWISSto12 SA, Switzerland)

16:50 ***3D Printed Compact Dual-Polarized Wideband Antenna***
Abdul sattar Kaddour (CEA-LETI, Minatec Campus, France); Serge Bories (CEA, France); Anthony Bellion (CNES, France); Christophe Delaveaud (CEA-LETI, France)
A novel compact dual-polarized unidirectional wideband antenna based on two crossed magneto-electric dipoles is proposed. The proposed miniaturization method consist in transforming the electrical filled square dipoles into vertical folded square loops. The surface of the radiating element is reduced to 0.23λ0*0.23λ0, where λ0 is the wavelength at the lowest operation frequency for a standing wave ratio (SWR) <2.5, which corresponds to a reduction factor of 48%. The antenna has been prototyped using 3D printing technology. The measured input impedance bandwidth is 51.2% from 1.7 GHz to 2.9 GHz with a Standing wave ratio (SWR) <2.

17:10 ***Resistively Loaded 3D Printed Antenna for GPR Applications***
Hugo Jenks (University of Bath, United Kingdom)
The resistively loaded 3D printed antenna demonstrates that commercially available thermoplastic filament which incorporates carbon particles can be used to print the radiating element directly, without any need to coat it with metal. Antennas used for Ground Penetrating Radar are generally resistively loaded in order to minimise late-time ringing which would obscure the returns from targets. Therefore radiation efficiency is not expected to be high. Wideband operation and good directivity are desirable characteristics of air-coupled GPR antennas, as realised here using a low cost fused filament 3D printer.

17:30 ***Rapid Prototyping of Waveguide and Horn Antennas***
Darren Cadman (Loughborough University, United Kingdom)
In this paper we review how fused deposition modelling (FDM) can be deployed for the rapid prototyping of microwave waveguide components and antennas. Additive manufacture of such objects allows new, novel and complex structures to be fabricated with lower impact on the environment relative to current manufacturing processes, plus the fast turnaround of design to manufacture and test. Additionally while the resulting physical antenna properties may not be perfect compared to the design or what can be machined, their RF/microwave performance can be quite forgiving thereby allowing the antenna design engineer to fully exploit the rapid prototyping concept.

17:50 ***Generation of Circularly Polarized Conical Beam Pattern Using (3,8)Torus Knot Antenna***
S Vinoth Kumar (Indian Institute of Technology, Kanpur, India); A. r. Harish (Indian Institute of Technology Kanpur, India)
A novel circularly polarized knot antenna with the conical beam radiation pattern is presented. It consists of a (3, 8) torus knot as a radiator which is excited by a monopole probe. Measured results show that the antenna has an impedance bandwidth of 39.6 % and axial ratio bandwidth of 26.8% covering the frequency range 3.0 GHz to 4.64 GHz. (3, 8) torus knot antenna is mechanically simple to fabricate using 3D printing technology. The proposed prototype is suitable for mounting on vehicles to facilitate communication with geostationary satellites.

18:10 ***Inkjet Printed Dual Band Antenna for Paper UAVs***
Sungyun Jun, Jonathan Heirons and Benito Sanz-Izquierdo (University of Kent, United Kingdom)
A dual band antenna is inkjet-printed and then folded as part of a paper unmanned aerial vehicle (UAV). The patterns of the antenna are reproduced on a standard photo paper substrate using an off the shelf inkjet printer. Readily available cartridges with nanoparticle silver conductive ink are employed. A single-layer planar antenna is fed by coplanar waveguide (CPW). The geometry of the radiating element consists of a semicircle with a centered square slot. In order to examine the effect of bending on performance, the antenna is tested unfolded and then folded when integrated onto the airplane. Two configurations of the folded antenna on the plane are analyzed. The aim is to investigate the feasibility of fabricating foldable antennas for paper airplanes using low-cost inkjet printing techniques. The antenna operates at the existing 2.4 GHz and 5.2 GHz WLAN bands. Finite different time domain simulations compare well with measurement.

CS36 Practical Applications of Characteristic Mode Theory to Antenna Design

Cellular Communications / Convened Session / Antennas
Oral Sessions: Room 342A
Chairs: Nader Behdad (University of Wisconsin-Madison, USA), Raj Mittra (Penn State University, USA)

16:50 ***Antenna Design for Smartphones Using Modal/Eigenmode Analysis***
George Shaker (University of Waterloo & Spark Tech Labs, Canada); Safieddin Safavi-Naeini (University of Waterloo, Canada)

Practical Antenna Design for handheld devices is demonstrated through the utilization of the modal/Eigenmode theory of antennas. Here, a review of the underlying design fundamentals is outlined. Next, a design example featuring the antenna design of a modern smartphone is presented. The design cycle is simplified through finding an antenna with appropriate complex resonance frequency to cover a required band. Locating the appropriate feed position is then a matter of extracting the corresponding impedance map for this antenna.

17:10 ***Design of a Dual-Band Platform-Mounted HF/VHFAntenna Using the Characteristic Modes Theory***

Mingjian Li (University of Wisconsin - Madison, USA); Nader Behdad (University of Wisconsin-Madison, USA)

In this paper, we report the results of a preliminary study of the design of dual-band platform-mounted antennas. In this approach, appropriately-designed coupling elements are employed to excite a desired platform mode to obtain an operating band in the HF frequency range. Moreover, the coupling elements are also designed to act as ultra-wideband radiators within the VHF frequency band. The coupling elements are modified loops with two feed points, one at each end of the loop and they can be excited either in the common or in the differential mode. When the coupling loops are fed differentially, they excites the fundamental mode of the platform resulting in an HF NVIS antenna. On the other hand, exciting the coupling loops in the common mode allows them to radiate as a vertically-polarized, omni-directional ultrawideband radiator operating in the VHF frequency band.

17:30 ***Design of an UHF UWB Doubled Annular Ring Antenna Using Characteristic Mode Analysis***

Qianyun Zhang and Yue Gao (Queen Mary University of London, United Kingdom)

In this paper, characteristic modes of a doubled annular ring are analyzed. Based on properties of significant radiating modes, energy radiated by dipoles close to the ring is coupled to excite the modes. Finally, resonances of multiple radiating modes join together and an ultra-high frequency (UHF) ultra-wide band (UWB) antenna is achieved.

17:50 ***Effects of Actual Antenna Excitation on Natural Radiation Modes***

Asim Ghalib (King Fahd University of Petroleum and Minerals, Saudi Arabia); Mohammad S. Sharawi (King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia)

In this paper, by using the Theory of characteristic modes (TCM), we analyze the effect of Inductive Coupled Elements (ICE's) used for the excitation of Characteristic Modes (CM) on antenna chassis. ICE's are used in sets to excite chassis modes and are placed at current maximas of the desired modes. Using TCM analysis, it was found that the introduction of such ICEs significantly affect the CM of the chassis and therefore can not be used as an efficient method for the excitation of CM. In addition, CM are compared with the total current generated on the surface and vicinity of a PIFA antenna. For normal excitation (not taking into account a single CM), a combination of modes are excited on the antenna chassis and surface depending on the frequency of interest. Also these currents are localized around the antenna.

18:10 ***Some Challenging Issues in Characteristic Mode Analysis of Real World Problems and Suggested Solutions***

Raj Mittra (Penn State University, USA)

The paper discusses the application of the Characteristic Mode Analysis (CMA) to a number of problems arising in practical antenna applications, and identifies some challenging issues that have been encountered by in the process of applying the CMA to some real-world problems. These include, among others, excitation of the Characteristic modes on complex platforms; antenna placement on these platforms to achieve a desired radiation pattern, specified over a limited angular range; determining excitation coefficients of antennas to achieve interference suppression of unwanted signals. It then goes on to present some systematic approaches to addressing these problems by modifying the conventional Characteristic mode analysis in a suitable manner.

TOP

CS06 Advances in Microwave Breast Cancer Diagnosis and Treatment (COST TD1301 MiMed)

Biomedical / Convened Session / Antennas

Oral Sessions: Room 342B

Chairs: Emily Porter (National University of Ireland Galway, Ireland), Adam Santorelli (McGill University, Canada)

16:50 ***A Portable Breast Cancer Imaging System with Cross-shaped Dome Antenna Array***

Hang Song and Hikaru Sato (Hiroshima University, Japan); Xia Xiao (Tianjin University, P.R. China); Takamaro Kikkawa (Hiroshima University, Japan)

Imaging of a breast cancer phantom was demonstrated by use of radar-based ultra-wide-band complementary metal oxide semiconductor integrated circuits (CMOS) with 16 cross-shaped dome array antennas on a hemispherical breast phantom. The dome antenna array was rotated and the combinations of transmitter and receiver antennas were selected by two CMOS switching matrices. A breast cancer phantom target in a silicone-based breast phantom was successfully detected by confocal imaging.

17:10 ***Bulk Permittivity Variations in the Human Breast over the Menstrual Cycle***

Jeremie Bourqui, Sasha Zarnke, Jacob Budzis, David Christopher Garrett, Daphne Mew and Elise Fear (University of Calgary, Canada)

A female volunteer is scanned daily using a system to measure bulk permittivity of the breast. The measured data are then compared to the volunteer's menstrual cycle. A permittivity increase of about 10% is found during the

luteal phase compared to the follicular phase of the cycle. This correlates with breast density increase reported with X-ray mammography during the luteal phase.

17:30 ***Manufacture and Testing of Anthropomorphic 3D-printed Breast Phantoms Using a Microwave Radar Algorithm Optimized for Propagation Speed***

Diego Rodriguez Herrera, Tyson Reimer and Mario Solis Nepote (University of Manitoba, Canada); Stephen Pistorius (University of Manitoba & CancerCare Manitoba, Canada)

Microwave imaging is a rapidly evolving modality. Microwave imaging systems have had clinical trials, but these typically require a lengthy regulatory approval process, numerous volunteers, and healthcare professionals. To allow for rapid yet realistic evaluation and refining of microwave imaging algorithms and systems, high-quality phantoms that mimic both the complex structure and dielectric properties of breast tissues are required. This work presents a design process that allows for breast phantoms to be modeled after MRI scans, along with a validation of the manufactured phantoms. The dielectric properties of the phantom materials were tested to ensure that they were similar to the properties of breast tissue. Breast phantoms were 3D-printed using the extracted MRI data and were tested using a clinical breast microwave-radar imaging system. The collected data were reconstructed using a holography algorithm that compensated for tissue density changes by adjusting the propagation speed.

17:50 ***Quasi-Real Time Reconstruction of the Complex Permittivity of Tissue Through Microwave Holography***

Daniel Tajik, Denys Shumakov, Alexander Beaverstone and Natalia Nikolova (McMaster University, Canada)

Quantitative microwave holography is a recently proposed imaging method that offers quantitative reconstruction in a quasi-real time. Since it is a direct inversion method, its utility is limited to weak-scattering problems. The feasibility of microwave holography in tissue reconstruction is studied here. The reconstruction results are promising, suggesting microwave holography is suitable as a linear inversion module within a nonlinear iterative procedure.

18:10 ***Towards the Assessment of Detection Limits in Magnetic Nanoparticle Enhanced Microwave Imaging of Breast Cancer***

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 have been recently proposed as a contrast agent for breast cancer microwave imaging. In this communication, we report on the ongoing activities aiming at the feasibility validation of magnetic nanoparticles enhanced microwave imaging. In particular, we discuss the results of some experiments, carried out to deal with the factors that influence the detection limits of the technique. Previous experiments have shown that a major limitation to the minimum amount of contrast agent that can be appreciated is due to the instrumental drift, which cannot be overcome by simply averaging the measurements. In addition, owing to the low level of the useful signal, possible magnetic effects arising from the system and the involved media can become relevant and impair the measurements. In the following, we deal with these aspects and describe how to overcome them, while preserving the detection capabilities of the technique. Results from relevant experiments are presented.

TOP

H_A01 Mm-Wave Antennas for High Data Rate III

High Data-rate Transfer / Regular Session / Antennas
Oral Sessions: Room 343
Chairs: Astrid Algaba Brazález (Ericsson Research, Ericsson AB, Sweden), Traianos Yioultsis (Aristotle University of Thessaloniki, Greece)

16:50 ***Dual-polarized Patch Array Antenna Package for 5G Communication Systems***

Jin-Kyoung Du, Kwangsup So, Yun Ra, Seung-Yoon Jung, Jongmoon Kim, Seung Yeon Kim, Seungmin Woo, Hong-Teuk Kim, Yo-Chuol Ho and Woohyun Paik (LG Electronics Inc., Korea)

For applications of 5G (5th generation mobile networks) communication systems, dual-polarized patch array antenna operating at 28.5 GHz is designed on the package substrate. To verify the radiation performance of designed antenna itself, a test package including two patch antennas is also design and measured its scattering parameter. Using a large height of dielectric materials, 1.5 ~ 2.0 GHz of antenna bandwidth is achieved which is wide enough. Besides, the dielectric constants are reduced to reflect variances of material properties in the higher frequency region. Measured results of the test package show a good performance at the operating frequency, indicating that the fabricated antenna package will perform well, either. In the future work, manufacturing variances will be investigated further.

17:10 ***Substrate-Integrated Planar Discrete Lens Antenna for Compact Millimeter-Wave Transceiver Module***

Kossaila Medrar (CEA Leti, France); Loic Marnat and Laurent Dussopt (CEA, LETI, Minatec, France)

A new topology of high-gain fixed-beam substrate-integrated planar antenna for packaged millimeter-wave transceiver modules is presented. It is based on a discrete planar lens antenna integrated on a thick dielectric substrate and illuminated by a focal source antenna placed on the opposite face of the substrate. The main objective of this architecture is to significantly enhance the integration of millimeter-wave transceiver modules with high-gain in-package antennas while using cost-effective technologies and fabrication processes. The concept is

demonstrated through the design of a linearly-polarized discrete-lens antenna operating at V band with a simulated gain of 18.1 dBi at 60 GHz and a 3-dB gain bandwidth of 24.4% (54-69 GHz).

17:30 ***Analysis and Design of a CSRR-based Fully Planar Substrate-Integrated Waveguide for Millimeter-Wave Circuits and Antennas***

Michalis Nitas, Maria - Thaleia Passia and Traianos Yioultsis (Aristotle University of Thessaloniki, Greece)

We present here a new design of a substrate-integrated waveguide (SIW), which is based on the use of a metamaterial-inspired periodic structure of coupled complementary split-ring resonators (CSRR). The resonators are etched on the metal surfaces that cover both sides of the dielectric substrate. The strong interaction between two side-by-side placed CSRRs provides the necessary means to block propagation through the ring structure and completely replace the series of via posts that is characteristic of a conventional SIW. The proposed transmission line has excellent propagation characteristics, since propagation losses are kept at levels comparable to those of the classic SIW, while the fully planar structure and the associated ease of implementation render the proposed SIW a strong alternative for a cost-effective implementation of millimeter-wave circuits and antennas.

17:50 ***Novel Paraffin-based 100-GHz Variable Capacitors for Reconfigurable Antennas***

Behnam Ghassemiparvin (The Ohio State University & ElectroScience Lab, USA); Spandan Shah and Nima Ghalichechian (The Ohio State University, USA)

We report multiphysics simulation of paraffin variable capacitors integrated with bent slot antenna to form a frequency reconfigurable structure. Paraffin is a low dielectric loss, phase change material that its solid-to-liquid transition exhibits 15% volumetric change. Here, we introduce low-loss paraffin phase change material (PCM) capacitors at 100 GHz that are monolithically fabricated with antennas. A frequency reconfigurable slot antenna loaded with paraffin PCM capacitors is designed that is capable of continuous frequency tuning in the range of 97.5-103.5 GHz. Antenna has a maximum gain of 3.78dBi and it is constant over the reconfiguration range. Actuation mechanism is analyzed in a multiphysics simulator. To characterize the deflection profile and the temperature distribution, it is crucial to fully couple the electric currents, heat transfer and solid mechanics. A new fabrication method for the deposition of the thin paraffin film is developed and a fabrication process for the reconfigurable antenna is presented.

18:10 ***Generation of Limited-Diffractive Twisted Pulses at Millimeter Waves***

Santi Concetto Pavone (Università degli Studi di Siena, Italy); Davide Comite (Sapienza University of Rome 1, Italy); Walter Fuscaldo (Sapienza University of Rome, Italy); Guido Valerio (Sorbonne Universités UPMC, France); Alessandro Galli (Sapienza University of Rome 1, Italy); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France); Matteo Albani (University of Siena, Italy)

In this paper, the generation of twisted pulses carrying orbital angular momentum is discussed. Such pulses are generated by polychromatic superposition of higher-order Bessel beams. The non-negligible effect of the wavenumber frequency dispersion on the pulse propagation at millimeter waves is taken into account. Large operating bandwidths are required to synthesize spatially confined electromagnetic pulses. For this reason, a wideband Bessel-beam launcher is proposed, implementing an inward cylindrical traveling-wave aperture distribution with an azimuthal phase variation. Preliminary results clearly show the possibility of successful generation of twisted electromagnetic pulses at millimeter waves.

TOP

F_P01 Numerical Radio Channel Modeling

Future Applications / Regular Session / Propagation

Oral Sessions: Room 351

Chairs: Conor Brennan (Dublin City University, Ireland), Tracy Haack (NRL-MRY, USA)

16:50 ***A High-Speed 2.5D Ray-Tracing Propagation Model for Microcellular Systems, Application: Smart Cities***

Taha Alwajeeh and Pierre Combeau (XLIM University of Poitiers, France); Rodolphe Vauzelle (XLIM, France); Ahcene Bounceur (Lab-STICC, UBO, France)

This paper introduces a new high-speed 2.5D deterministic radio propagation model. This model is suitable for outdoor urban configurations where transmitter and receiver nodes are below the rooftop level of the surrounding buildings. In this paper we combine three acceleration strategies in order to achieve a high-speed site-specific microcellular model. The first strategy is an efficient implementation of a ray-tracing model based on the visibility tree technique. The second strategy is to consider only a limited portion of the propagation environment that has a significant contribution on the received signal. The third strategy is based on a pre-calculation of the exact 2D visibility trees, in order to be used to reconstruct quickly all the possible paths.Simulation results for the implemented ray-tracing model are compared with measurements. Then, the other acceleration techniques were combined to further reduce the execution time to the minimum extent with a small impact on the accuracy

17:10 ***An Intra-Visibility Matrix Based Environment Pre-Processing for Efficient Ray Tracing***

Sajjad Hussain and Conor Brennan (Dublin City University, Ireland)

This paper presents a new approach to compute the image tree of given order of ray interaction for ray-tracing. The intra-visibility of walls and vertical edges along with their angular position in the visibility region is computed. The image tree is readily created as the angular information is used to determine if a wall or vertical edge lies within an image illumination zone. Validation results show a considerable reduction in run times for image tree computations. The elimination of a recursive visibility algorithm for image tree creation is a first step towards

efficient ray-tracing in mobile transmitter scenarios such as in vehicular networks.

17:30 ***Predicting Radio Frequency Sensor Performance with Numerical Models***

Tracy Haack (NRL-MRY, USA); Rachel Norris (University of Michigan, USA); Hedley Hansen (DSTO, Australia); Amalia Barrios (SPAWAR-Systems Center Pacific, USA); Andrew Kulessa (Airborne Research Australia)

Radio frequency (RF) propagation is highly dependent upon the vertical distribution of moisture and temperature along the transmission path. Vertical gradients in the atmosphere can alter normal propagation, producing sub-refraction, super-refraction or trapping conditions. The U.S. Navy employs a high resolution numerical weather prediction (NWP) model to forecast these gradient structures and their mesoscale variability. In this research we explore the fidelity of propagation loss predictions obtained using an NWP environment with measured data collected during the Tropical Air-sea Propagation Study (TAPS), a campaign that took place off the northeastern coast of Australia in Nov/Dec 2013 [1]. We demonstrate good agreement with Ka-Band path loss prediction to those received by a ship mounted MIMO system for ranges up to 45-50 km from the shore-based transmitter and investigate relationships between propagation loss, the evaporation duct height, and environmental parameters.

17:50 ***Propagation Aspects for RF Fingerprinting at Open Areas over Irregular Terrain***

Eran Greenberg and Pascal Levy (RAFAEL, Israel)

Ray tracing simulations are used to investigate the RF fingerprinting in open areas over irregular terrain profiles. We show that these simulations can project the RF signature exclusiveness of an emitter location in space by means of received power, mean azimuth DoA and delay spread heat maps. Additionally, full-3D ray-tracing simulations allow us to investigate the amount of energy inside and outside the plane of incidence and to classify it according to the terrain profile type and LOS/NLOS. The methodology presented will permit evaluation of the traditional geometric method and the RF fingerprinting technique for position determination.

18:10 ***Hybrid Formulation for the Electromagnetic Analysis of Metallic Objects Placed in Natural Environments***

Lydia Hettak (Sorbonne Universités, France); Hélène Roussel (Sorbonne Université UPMC Paris 06, France); Massimiliano Casaletti (Sorbonne Universités UPMC, France); Cyril Dahon (Sorbonne Universités, UPMC, France); Raj Mittra (Penn State University, USA)

The main objective of our work is to develop an efficient model for the electromagnetic scattering from large scenes composed by targets (metallic objects) placed in natural environment (dielectric objects). A hybrid volume/surface model is used to describe both forest environments and metallic structures. Large portion of forest can be analyzed using a CBFM approach able to significantly reduce the dimension of the linear system that has to be solved.

TOP

CS38 Propagation Aspects in Remote Sensing

Radars / Convened Session / Propagation

Oral Sessions: Room 352A

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

16:50 ***Propagation Effects in the Application of Weather Radar - Positive and Negative Impact***

Martin Hagen and Jens Reimann (Deutsche Zentrum fuer Luft- und Raumfahrt, Germany)

Propagation effects play in important role in the application of weather radar. Attenuation and depolarization have negative effects on the quality of radar data and hinder rainfall estimation, whereas the differential propagation phase can be used for the quantification of precipitation and even correction of attenuation effects.

17:10 ***Decrypting XPD-CPA Beacon Measurements Through a Physical Simulator***

Eric Regonesi and Carlo Capsoni (Politecnico di Milano, Italy); Roberto Nebuloni (Ieiit - Cnr, Italy); Carlo Riva and Lorenzo Luini (Politecnico di Milano, Italy)

Complex physical models are necessary to interpret the patterns of microwave attenuation versus depolarization gathered from measurements along Earth-to-satellite paths, due to the layered structure of the atmosphere in the presence of precipitation or clouds. Here we show that a simulation tool previously developed and based on physical concepts achieves good results when checked against measured patterns in a few case studies. Upon further validation, the simulator could be useful in assessing the effects of interference in the design of satellite systems based on polarization diversity.

17:30 ***Path Length in Rain Media and Effective Path Length Derived from Weather Radar Measurements***

Franz Teschl, Reinhard Teschl and Helmut Paulitsch (Graz University of Technology, Austria)

For a variety of propagation and remote sensing questions, the knowledge on the length, microwaves propagate through rain media, is relevant. Weather radar measurements allow studying the effect for a given location in various directions and elevation angles, representing both terrestrial and satellite paths. This study uses raw data from an operational weather radar to retrieve statistics on how frequent slant paths through the atmosphere propagate through a certain length of rain. The same dataset is also used to derive attenuation statistics and values for the effective path length, as it is defined in relevant recommendations of the ITU-R, and the study shows a proper correlation.

17:50 ***Accurate Characterization of Rain Drop Size Distribution Using Meteorological Particle Spectrometer and 2D Video Disdrometer for Propagation and Remote Sensing Applications***

Merhala Thurai, Viswanathan Bringi and Patrick Kennedy (Colorado State University, USA); Branislav Notaros (Colorado State University at Fort Collins, USA); Patrick Gatlin (NASA-MSFC, USA)

Accurate measurements of rain drop size distributions (DSD), with particular emphasis on small and tiny drops, are presented. Measurements were conducted in two very different climate regions, namely Northern Colorado and Northern Alabama. Both datasets reveal a combination of (i) a drizzle mode for drop diameters less than 0.7 mm and (ii) a precipitation mode for larger diameters. Scattering calculations using the DSDs are performed at S and X bands and compared with radar observations for the first location. Our accurate DSDs will improve radar-based rain rate estimates as well as propagation predictions.

18:10 ***The Variability of Atmospheric Refractivity and Its Impact on Remote Sensing***

Robert J Watson and Balsubramani Goudar (University of Bath, United Kingdom)

In the absence of precipitation, one of the most significant factors affecting signals propagating through the troposphere is the atmospheric refractivity. Changes in atmospheric refractivity due to water vapour introduces variable path delay error for signals propagating through this environment. This paper provides a brief review of how variability of refractivity affects remote sensing systems and describes a method of estimating refractivity using signals of opportunity and an inverse method.

TOP

L_A05 Wire & Loop Antennas

Localization & Connected Objects / Regular Session / Antennas

Oral Sessions: Room 352B

Chairs: Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain), Mohamed Himdi (Université de Rennes 1, France)

16:50 ***Design Methodology of Single-feed Compact Near-Isotropic Antenna Design***

Zhen Su (King Abdullah University of Science and Technology, Saudi Arabia); Farhan Ghaffar (KAUST, Saudi Arabia); Muhammad Farooqui, Rana Bilal and Atif Shamim (King Abdullah University of Science and Technology, Saudi Arabia)

The abundance of mobile wireless devices is giving rise to a new paradigm known as Internet of Things. Since the wireless sensing devices will be oriented randomly in the environment, they should be able to communicate equally in all directions in order to have stable communication link. Hence, compact near isotropic antennas are required, which can enable orientation insensitive communication. In this paper, we propose a simple design methodology to design a compact near-isotropic wire antenna based on equal vector potentials. As a proof of concept, a quarter wavelength monopole antennas has been designed that is wrapped on a 3D-printed box keeping the vector potentials in three orthogonal different directions equal. By optimizing the dimension of the antenna arms, a nearly isotropic radiation pattern is thus achieved. The results show that the antenna has a maximum gain of 2.2dBi at 900 MHz with gain derivation of 9.4dB.

17:10 ***Analysis of Strip Antennas Located on the Interface Between a Uniaxial Plasma and an Isotropic Medium***

Alexander Kudrin (University of Nizhny Novgorod, Russia); Tatyana M. Zaboronkova (University of Nizhny Novgorod); Anna Zaitseva (University of Nizhny Novgorod, Russia); Catherine Krafft (Ecole Polytechnique, France)

Straight and annular strip antennas located on the interface between a uniaxial plasma and an isotropic medium are considered. Integral equations for the current distributions of such antennas are derived and analyzed in the case where the plasma is resonant. Approximate closed-form solutions of the integral equations for narrow strip antennas are obtained for practically important situations. It is concluded that the replacement of a magnetoplasma by a relatively simple model of uniaxial medium almost does not affect the description of the characteristics of the considered narrow strip antennas.

17:30 ***Performances of Monopole Plasma Antenna***

Oumar Barro (Institute of Electronics and Telecommunications of Rennes, (IETR) University of Rennes 1, France); Mohamed Himdi (Université de Rennes 1, France); Olivier Lafond (IETR, France)

This paper presents the performance of monopole plasma antenna. The plasma tube is used as radiating element. The antenna is designed and works at different frequencies. To couple electromagnetic signal from the coaxial probe to the plasma column, a coupling system is realized. It permit the tube to radiate in order to design a monopole antenna. The performances of the monopole are given in terms of S11, gain and radiations patterns.

17:50 ***A Wideband Dipole Antenna Based on a Non-Uniformly Segmented Structure***

Haihan Sun (University of Technology, Sydney, Australia); Can Ding (University of Technology Sydney (UTS), Australia); Y. Jay Guo (University of Technology, Sydney, Australia); Raj Mittra (Penn State University, USA)

The design of a wideband, vertically polarized omnidirectional dipole antenna based on a non-uniformly segmented structure is presented. The proposed non-uniformly segmented configuration mitigates the phase change of the currents flowing in the long dipole arms, so that the reverse currents which deteriorate the radiation pattern can be avoided, and a stable omnidirectional pattern can be maintained over a wide frequency band. Simulation results

show that the proposed dipole has a wide pattern bandwidth of 66%, ranging from 1.96 GHz to 3.90 GHz, with S11 less than -10 dB. Within the band, the main lobe of the dipole remains in the broadside direction in the E-plane and the antenna achieves the desirable omnidirectional radiation pattern, with a gain flatness of less than 0.3 dB in the H-plane.

18:10 ***Design of a Low Profile Unidirectional UWB Antenna for Multi-service Base Station***

Carlos Ramiro Peñafiel-Ojeda (Universitat Politècnica de València & Universidad Nacional de Chimborazo, Spain); Marta Cabedo-Fabrés and Nora Mohamed Mohamed-Hicho (Universidad Politécnica de Valencia, Spain); Miguel Ferrando-Bataller (Universidad Politecnica De Valencia, Spain)

A low profile unidirectional UWB antenna for multi-service base stations is presented in this paper. The main goal of this article is to design a low profile UWB antenna with a very stable and unidirectional radiation pattern. The proposed design is based on exciting the fundamental mode of a planar structure composed of two metallic rings, applying the Theory of Characteristics Modes(TCM). The feeding structure used to excite that mode is asymmetric and it is implemented with two CPW-ports (Co-planar Waveguide) with an impedance of 50Ω, that bifurcate into two transmission lines with different lengths that are coupled to a circular aperture using the slot line model. The design has been obtained using a mathematical formulation, so it can be easily scaled to any frequency. Additionally, an analysis of the operation of the structure is performed, according to TCM. The -10dB bandwidth obtained is 64.22%, with unidirectional radiation patterns.

TOP

R_P03 Imaging and Inverse Scattering

Radars / Regular Session / Propagation

Oral Sessions: Room 353

Chairs: Carey Rappaport (Northeastern University, USA), Xiuzhu Ye (Beihang University, P.R. China)

16:50 ***Experimental Validation of a GPR Imaging System***

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

Experimental evaluation of a Ground Penetrating Radar (GPR) system is presented. The method is based on an Underground-SAR imaging algorithm that takes into account the complex permittivity of the soil to compensate for the slower wave propagation so that buried objects are imaged at the correct depth. The proposed GPR imaging system is devoted to operate in C band, from 3.5 to 5.5 GHz, in order to enhance lateral resolution thanks to the higher operating frequency. The 2 GHz frequency bandwidth enables 7.5 cm range (or depth) resolution. Several cases with different Tx/Rx hardware and antennas have been tested in order to analyze the influence in the recovered SAR images. 2D-MoM simulations have been done to evaluate the agreement with experimental results as well.

17:10 ***Study of Geophysical Model Functions for Inverse Problem of Sea Surface Scattering***

Tran Vu La (ENSTA Bretagne, France); Ali Khenchaf (ENSTA Bretagne & LAB-STICC UMR CNRS 6285, France); Fabrice Comblet (ENSTA Bretagne, France); Carole Nahum (Direction Générale de l'Armement, France); Helmi Ghanmi (ENSTA Bretagne, France)

In addition to image processing and neural network, inverting the Geophysical Model Functions (GMFs) is one of the most widely used ways to retrieve oceanic parameters, i.e. surface wind speed, temperature, salinity, etc., from Synthetic Aperture Radar (SAR) data. More exact the description of the GMFs is, more accurately the results are obtained. For this problem, one can find two principal approaches: empirical (EP) GMFs based on in situ measurements and electromagnetic (EM) GMFs based on EM calculations of radar scattering from sea surface roughness. In order to explore the potentials of the GMFs for inverse problem in C-band, we compare in this paper radar scattering calculated by CMOD5.N (EP GMF), and TSM and SSA (EM GMFs). Likewise, we compare wind speed estimates by inverting the studied GMFs. Based on comparisons, several solutions may be proposed to improve the calculation of radar scattering, and then the retrieval of oceanic parameters.

17:30 ***Computational Frequency-Diverse Microwave Imaging Using an Air-Filled Cavity-Backed Antenna***

Okan Yurduseven (Duke University, USA); Thomas Fromenteze (Duke University, France); Jonah Gollub, Daniel Marks and David Smith (Duke University, USA)

We demonstrate a frequency-diverse imaging system using an air-filled cavity-backed antenna as a transceiver (cavity-to-cavity system layout) for the K-band (17.5-26.5 GHz) frequency regime. Leveraging the computational imaging concept, the frequency-diversity enables imaging in an all-electronic manner, without the need for mechanical raster scanning or active circuit components, minimizing the data acquisition time and simplifying the system architecture. It is shown that the proposed system is capable of reconstructing good fidelity images in a sub-second time frame, holding significant potential for real-time imaging applications.

17:50 ***Quantitative Imaging Using Scattering Matrix: Influence of the Polarization***

Christelle Eyraud (Institut Fresnel, Aix Marseille Université, CNRS, Centrale Marseille, France); Jean-Michel Geffrin (Institut Fresnel & Aix Marseille Univ, CNRS, Centrale Marseille, France); Hassan Saleh (Centre Commun de Ressources en Microondes, Institut Fresnel, France)

This paper deals with the polarization aspect in 3D inverse scattering. The vectorial information contained in the scattering matrix is often under-exploited in quantitative inverse scattering problems even if it has been

expensively studied in radar processing. In this work, we present a study of the influence of the polarization state of the electromagnetic wave on the reconstructed permittivity maps. Reconstructions performed from measurements in different polarization cases will be compared and discussed.

18:10 ***A Quantitative Investigation of Through theWall Imaging***

Mohammad Zoofaghari (Yazd University, Iran)

It is important to know which parts of an inspection domain could be suitably reconstructed in through the wall imaging (TWI). It is also of interest to find a frequency range for which a reconstruction algorithm is efficient. For these purposes, a quantitative investigation of the coverage area and frequency bandwidth of the imaging setup is introduced. The imaging process is based on the linear sampling (LSM) as a well-known qualitative method in the literature. The method is very effectual since it is fast and robust against noise. We need the background Green's function for the realization of LSM which is derived recently by the authors. The frequency bandwidth of the imaging algorithm would be obtained by calculation of a resemblance coefficient (RC) for the various frequencies. Here we also define a new parameter named coverage area (CA) and discuss a scenario to find it.

TOP

F_M03 Material Measurements

Future Applications / Regular Session / Measurements

Oral Sessions: Room 362/363

Chairs: Branko Kolundzija (University of Belgrade, Serbia), Maxim Zhadobov (University of RENNES 1, France)

16:50 ***Carbon Fiber Reinforced Polymer as Antenna Ground Plane Material Up to 10 GHz***

Gerald Artner, Robert Langwieser and Christoph F Mecklenbräuker (Vienna University of Technology, Austria)

Carbon Fiber Reinforced Polymer (CFRP) or generally Carbon Fiber Composites (CFC) are increasingly utilized in lightweight construction. Large CFRP parts such as chassis or fuselages are utilized as antenna ground planes. However, radiation characteristics of antennas designed for metal ground planes change when mounted on anisotropic composites. In this paper the influences of CFRP ground planes on the radiation characteristics of antennas in the range from 1 - 10 GHz are investigated with measurements of conical monopole antennas. Measurements show that ground planes from unidirectional CFRP severely distort radiation patterns, while the influence of woven plies is small.

17:10 ***Evaluation of OAM-radio Mode Detection Using the Phase Gradient Method***

Timothy Drysdale (The Open University, United Kingdom); Ben Allen (University of Oxford & Network Rail, United Kingdom); Eduardo Cano (University of Bedfordshire, United Kingdom); Qiang Bai and Alan Tennant (University of Sheffield, United Kingdom)

In this paper the detection of Orbital Angular Momentum (OAM) modes at a carrier frequency of 10 GHz is evaluated by modelling and by experimentation. A 2-element antenna array and the phase gradient detection method is used to determine whether a mode 0 or -1 is present, where our results verify that a distinct difference in measured phase profile between the two modes is distinguishable even in the presence of a multipath reflection. The measured influence of the multipath reflection is shown to agree well with modelling results. Our model combines full-wave simulations of transmit and receive antennas with a ray tracing model, revealing the respective influence of the direct and reflected multipath components of the signal. Consequently, our work shows novel insights confirming the behaviour of an OAM radio signal with a dominant reflected component and subsequent performance of the detector through experimentation.

17:30 ***Emulating Magnetic Ferrite Tiles Properties by WIPL-D Software Suite***

Branko Kolundzija (University of Belgrade, Serbia); Milos Pavlovic (WIPL-D DOO, Serbia)

The focus of this paper is emulation of ferrite tile characteristic in WIPL-D Pro 3D EM solver. Usually the characteristic itself is unknown, while the performance characteristic is provided in standard datasheets. By using a relatively simple expressions for EM properties of material, we can proceed to optimize their performance until they reach the specification given in datasheets. A coaxial tube method (employed in EM solver) is used as emulation tool, with simulation and optimization performed in WIPL-D software suite. The material in question was selected as TDK IB-017. With the advanced mathematical model for the EM properties, a better agreement can be achieved.

17:50 ***Evaluation of Currents Induced in Human Body by Plane Wave Exposure At 1-90 MHz***

Jeanne Frere (IETR, University of Rennes 1 & Thales Communications & Security, France); Alain Alcaras (Thales Communications & Security, France); Maxim Zhadobov (University of RENNES 1, France); Christophe Lemoine (IETR, France); Gwenaël Le Cadre (Thales Communications & Security, France); Ronan Sauleau (University of Rennes 1, France)

In existing exposure standards and guidelines the relationship between dosimetric quantities at a given frequency is not always consistent as some simultaneously applied limits are more restrictive than others, e.g. limits on induced currents compared to those on external electric field or specific absorption rate (SAR). To evaluate the current induced in the human body in 1 - 90 MHz range, we propose an equivalent circuit composed of two elements: the first one provides the voltage at human body mid-height and the second one describes the equivalent human body impedance. Then, assuming that the human body is equivalent to an antenna between 1 and 90 MHz, we calculate induced currents at the human body height. Using the relationship between external electric field and voltage at the body mid-height, we calculate the current along the body and suggest updated limits on induced currents more consistent with the external electric field limits.

18:10 ***Experimental Evaluation of UWB Applicator Prototype for Head and Neck***

Hyperthermia

Pegah Takook (Chalmers University of Technology, Sweden); Masoud Shafiemehr (Volvo car group, Sweden); Mikael Persson and Hana Dobšíček Trefná (Chalmers University of Technology, Sweden)

The laboratory prototype of an UWB hyperthermia applicator is presented and tested for treatment of tumors in head and neck region. The focusing ability of the presented applicator for treatment of neck tumors has been tested on a homogeneous muscle phantom at 500 MHz. Two tumor positions were investigated: one in the center and one in the side of the mid-transverse plane of the phantom. The captured temperature images show the agreement between the planned and the measured focal spots and acceptable temperature increase in these areas.

Friday, March 24

Friday, March 24, 08:40 - 10:00

TOP

Sp_A02 Reflector & Lenses for Space Applications

Space / Regular Session / Antennas

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia), Arthur D Yaghjian (Electromagnetics Research Consultant, USA)

08:40 ***Design of an X-Band Feed System for the Auckland University of Technology 30m Diameter Warkworth Radio Telescope***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); John Kot (Young & Kot Engineering Research, Australia); Tim Natusch, Stuart Weston and Sergei Gulyaev (Auckland University of Technology, New Zealand)

An innovative way to nest a new X band feed system inside an existing C band feed system is proposed.

09:00 ***On the Design of Uncooled Wideband Direct Detection Focal Plane Arrays***

Sven van Berkel and Ozan Yurduseven (Delft University of Technology, The Netherlands); Angelo Freni (Università degli studi Firenze, Italy); Andrea Neto and Nuria LLombart (Delft University of Technology, The Netherlands)

In millimeter and sub-millimeter wave imaging systems a persistent goal is the increase in sensitivity and Field-of-View of the system. Typically the highest sensitivity is achieved by cryogenically cooling the detectors, specifically in satellite based astronomic applications. However, good sensitivities can also be achieved by using tens thousands of receivers utilizing a very broad portion of the THz-band. This leads to uncooled integrated detection solutions suitable for low-cost imaging applications. In wideband systems the optimal sampling configuration will be a trade-off between imaging speed and resolution. In this contribution we will investigate the optimal sampling configuration in terms of imaging speed as function of bandwidth, considering the system is detector-noise limited. Using a leaky-lens FPA with a relative bandwidth of 1:5 results in an increase in imaging speed of a factor 45 w.r.t. a 1:1.5 horn antenna FPA, at the cost of a 4.17 times lower resolution.

09:20 ***Analysis and Design of a Continuous Parallel Plate Waveguide Multiple Beam Lens Antenna At Ku-Band***

François Doucet (IETR - University of Rennes 1, France); Nelson Fonseca (European Space Agency, The Netherlands); Etienne Girard (Thales Alenia Space, France); Hervé Legay (Thalès Alenia Space, France); Ronan Sauleau (University of Rennes 1, France)

This paper presents the description and analysis of a continuous parallel plate waveguide (PPW) lens-like beamformer. The main design parameters of the continuous delay lens are defined starting from an ideal bifocal constrained lens. A dedicated ray tracing analysis tool is developed to better describe propagation effects in the delay lens and provide more insight on phase aberrations versus pointing angle. Numerical results of a specific design at Ku-band are reported by comparing radiation patterns obtained with the ray tracing tool and a full-wave method. These results are also compared to the ideal bifocal constrained lens design.

09:40 ***Metasurface Waveguides Applied to Matched Feeds for Reflector Antennas***

Michael Palvig (Technical University of Denmark & TICRA, Denmark); Erik Jørgensen and Peter Meincke (TICRA, Denmark); Olav Breinbjerg (Technical University of Denmark, Denmark)

Waveguides with anisotropic surface impedance boundaries have been investigated for the purpose of matched feeds for offset reflectors. Matched feeds employ higher order waveguide modes to cancel out cross polarization introduced by the offset geometry. Since the higher order modes propagate at different speeds than the fundamental mode in conventional waveguides, it is challenging to meet phase relationship requirements over a large band. We have found that traditional corrugated waveguides are poorly suited for matched feed applications. However, other surfaces that satisfy the balanced hybrid condition, but have a small capacitive longitudinal reactance and large inductive azimuthal reactance show very promising properties: In a large band, HE11 and HE21 have similar propagation characteristics.

F_A03 Antennas for future Applications

Future Applications / Regular Session / Antennas
Oral Sessions: Room 341
Chairs: Manuel Arrebola (Universidad de Oviedo, Spain), Santi Concetto Pavone (Università degli Studi di Siena, Italy)

08:40 ***A Compact Satellite Antenna Module for GPS, Galileo, GLONASS, BeiDou and SDARS in Automotive Application***
Iuliia Goncharova (University of the Bundeswehr, Munich, Germany); Stefan Lindenmeier (Universität der Bundeswehr, Germany)
A new design concept of a compact satellite antenna module for automotive application is presented, enabling mobile reception of all common navigation systems, e.g. GPS in L1&L2 bands, Galileo, GLONASS, BeiDou, as well as reception of satellite digital audio radio service (SDARS). A new design concept allows easy fabrication in combination with high reception properties. The performance of the antenna module, fulfilment of the requirements of car manufacturers and service providers is proven by simulated and measured results, showing the high realized gain for circular polarization, efficiency, matching and decoupling against terrestrial interferers.

09:00 ***Near Field Synthesis of Reflectarrays Using Intersection Approach***
Álvaro Fernández Vaquero (Universidad de Oviedo, Spain); Daniel R. Prado (Universidad de Oviedo & Group of Signal Theory and Communications, Spain); Manuel Arrebola, Marcos R. Pino and Fernando Las-Heras (Universidad de Oviedo, Spain)
In this work, the Intersection Approach algorithm is adapted to perform near field synthesis of reflectarray antennas. First, a brief description of how the near field radiated by the reflectarray is presented. Then, the algorithm is detailed, in particular, the definition of the forward and backward projectors. Unlike as the far field version of the Intersection Approach, for near field synthesis the backward projection cannot be implemented by a Fast Fourier Transform, and another strategy is employed, namely, the use of a general minimization algorithm, the Levenberg-Marquardt algorithm in this case. Finally, the algorithm is validated with a near field optimization consisting on generating a planar field amplitude in a volume for applications such as RFID tag identification or wireless short range coverage.

09:20 ***Wideband Analysis of RLSA Bessel Beam Launchers Based on Standing and Inward Traveling Wave Aperture Distributions for Electromagnetic Pulse Generation***
Santi Concetto Pavone (Università degli Studi di Siena, Italy); Agnese Mazzinghi and Angelo Freni (University of Florence, Italy); Matteo Albani (University of Siena, Italy)
In this paper, the dispersion properties of RLSA Bessel beam launchers, realized by enforcing both cylindrical standing wave and inward traveling wave aperture distributions, are compared. In particular, it is shown that such launchers can be profitably used for the generation of electromagnetic localized pulses at millimeter waves.

09:40 ***The Time-Dependent ACGF with Applications to M-ary Digital Communication Systems***
Said Mikki and Ahmed S Hanoon (University of New Haven, USA); Jocelyn Aulin (Huawei Technologies Sweden AB, Sweden); Yahia Antar (Royal Military College of Canada, Canada)
We provide a complete and exact space-time system model for arbitrary antennas valid for generic field excitations. The method is based on introducing a time-dependent extension of the antenna current Green's function (ACGF). It is shown that this approach is more general than the conventional impulse response model by proving that for generic antennas an impulse response may not exist. A complete antenna-field-digital communication link is analyzed using the method and the optimum receiver structure matched to any given antenna and electromagnetic field illumination is derived.

Friday, March 24, 08:40 - 11:50

CS33 OTA Characterization of Antennas and Devices from RIMP to Random-LOS and all in Between

Cellular Communications / Convened Session / Measurements
Oral Sessions: Room 342A
Chairs: Andrés Alayon Glazunov (Chalmers University of Technology, Sweden), Christian Lötbäck (Bluetest AB, Sweden)

08:40 ***Reproducing Standard SCME Channel Models for Massive MIMO Base Station Radiated Testing***
Wei Fan and Fengchun Zhang (Aalborg University, Denmark); Tommi Jamsa (Tommi Jamsa Consulting & Huawei Technologies Sweden, Finland); Mattias Gustafsson (Huawei Technologies Sweden AB, Sweden); Pekka Kyösti (Keysight Technologies & University of Oulu, Finland); Gert Pedersen (Aalborg University, Denmark)

Massive MIMO is a multi-user technology, where radio base stations (BSs) are equipped with a large number of antennas to simultaneously serve many terminals in the same time-frequency resource. Performance evaluation of such large-scale antenna systems in the design and development stage is challenging. In this paper, we propose to evaluate massive MIMO BSs with a sectorized multi-probe anechoic chamber (MPAC) setup. A sectorized MPAC setup with 16 probe antennas distributed uniformly within $[-60^o, 60^o]$ in azimuth domain is utilized to reproduce target channel models. A 8×8 and a 16×16 uniform planar array at 3.5 GHz are selected as the BS under evaluation, respectively. Radio channel emulation accuracies in terms of power-angular spectrum, spatial correlation and beamforming pattern are investigated for the proposed MPAC setup and desired channel models.

09:00 ***Measuring Massive MIMO Array Systems Using Over the Air Techniques***

Doug Reed and Alfonso Rodriguez-Herrera (Spirent Communications, USA); Ronald Borsato (PCTEST Engineering Laboratory, USA)

Emulation of a realistic environment is modeled in an anechoic chamber to measure the performance of a Base Station Massive MIMO Array antenna using a Spatial Channel Model. The first bounce path establishes the angles of departure and angle spreads observed by the MM array and each is produced by probes placed in the chamber. A channel emulator is utilized to model the full connection between the BS and MS. Additional probes are used to emulate additional multi-path components.

09:20 ***Over-The-Air Evaluation and Ranking of Mobile Phone Performance***

Anders Karstensen and Gert Pedersen (Aalborg University, Denmark)

This paper presents an investigation of the radio performance of 26 mobile phones common in the Nordic countries. Antenna performance in terms of total isotropic sensitivity (TIS) and total radiated power (TRP) of different phone models was measured. The investigation includes results for talk mode using left and right hand phantoms next to head, as well as data mode using only the hand phantom. Large variations in the performance between the various phone models were found, especially in talk mode.

09:40 ***Spatial Fading Emulator - Early OTA Device in Japan***

Jun-ichi Takada (Tokyo Institute of Technology, Japan); Koichi Ogawa (University of Toyama & Faculty of Engineering, Japan); Kei Sakaguchi (Tokyo Institute of Technology & Fraunhofer HHI, Japan)

The authors have investigated on the spatial fading emulator comprised of multiple antenna elements emulating the spatially distributed scatterers to generate the fading in the reproducible manner since 2001. This paper presents the history of early development until 2010 when MIMO OTA test was a very popular topic. The motivation, ideas and achievements are reviewed and summarized, because some important papers were not published in English nor on major journals nor international conferences, and such kind of review has not yet been conducted by now.

10:00 Coffee Break

10:30 ***New Challenges in Over-The-Air Testing***

Wim A. Th. Kotterman and Christopher Schirmer (Technische Universität Ilmenau, Germany); Markus Landmann (Fraunhofer Institute for Integrated Circuits IIS, Germany); Giovanni Del Galdo (Fraunhofer Institute for Integrated Circuits IIS & Technische Universität Ilmenau, Germany)

Two OTA test methods from literature are selected as those most suited for testing future 5G equipment when assessing end-to-end performance: coherent wave-field synthesis and radiated two-stage or "Wireless Cable". Both methods have their advantages and disadvantages. Wave-field synthesis is transparent for antenna characteristics of Equipment-under-Test but not viable for large test objects. The Wireless Cable puts no direct size constraint on Equipment-under-Test but requires antenna pattern measurements beforehand and cannot cope with dynamically adaptive antenna patterns. Other methods from literature show deficits regarding real-time testing or accuracy of the angular distribution of emulated radio fields.

10:50 ***Assessing Measurement Distances for OTA Testing of Massive MIMO Base Station at 28 GHz***

Pekka Kyösti (Keysight Technologies & University of Oulu, Finland); Wei Fan (Aalborg University, Denmark); Jukka Kyröläinen (Keysight Technologies Finland oy, Finland)

This paper discusses physical dimensions for a multi probe anechoic chamber based (MPAC) over-the-air (OTA) setup aiming for base station (BS) testing. The target frequency of the simulated massive multiple-input-multiple-output (MIMO) BS arrays is 28 GHz. The assessment is performed with two metrics. The first metric is a new power metric based on assumptions of a code book of fixed beams and planar waves. The second one is the multi-user (MU) MIMO sum rate capacity. The intention is to evaluate physical dimensions in metres with respect to different BS array sizes. Simulation results indicate that OTA performance of a BS array with maximum dimension of 0.15m could be measured with a setup having measurement distance of approximately 1m.

11:10 ***Evaluation of Combined TIS for High Order MIMO System in Mobile Terminal***

Kun Zhao (KTH Royal Institute of Technology & Sony Mobile Communication AB, Sweden); Zhinong Ying (SONY Mobile Communications AB, Sweden); Sailing He (Royal Institute of Technology, Sweden)

the maximum ratio combined TIS of high order MIMO system in a real phone prototype is presented in this paper. The value of combined TIS is estimated through antenna pattern combination and verified by experiments. The impact from the order of MIMO system, the propagation model and the user body effect are investigated.

11:30 ***The Critical Importance of Accurate Channel Modelling for the Success of mmWave 5G***

Moray Rumney (KeysightTechnologies, United Kingdom)

The move of cellular communications from existing frequencies predominantly below 3 GHz up to the lower end of the mmWave bands around 28 GHz and higher, is set to change everything about how we design, test and operate such systems. The successful launch of a new radio (NR) access system is critically dependent on a correct understanding of the quasi-optical propagation behaviour of narrow beamwidth mmWave signals. The development of accurate channel models will correctly inform the NR specifications and equipment design, then finally the test requirements. However there is not yet consensus across these four domains on key parameters such as the number of usable beams, their angular width and their dynamics in terms of spatial consistency, power, time dispersion and frequency dependency. This paper examines explains the need to make coordinated progress across the industry to ensure a timely and technically successful deployment of mmWave 5G.

CS12 Developments in Electromagnetic Medical Interventions (COST TD1301 MiMed and COST BM1309 EMF-MED)

TOP

Biomedical / Convened Session / Antennas
Oral Sessions: Room 342B
Chairs: Margarethus M. Paulides (Erasmus University Medical Center, The Netherlands), Desmond Teck Beng Yeo (GE Global Research, USA)

08:40 ***Advances in Magnetic Resonance Guided Radiofrequency Hyperthermia***
Margarethus M. Paulides and Sergio Curto (Erasmus University Medical Center, The Netherlands); Mingming Wu (Technical University of Munich, Germany); Lukas Winter (Max Delbrueck Center for Molecular Medicine in the Helmholtz Association, Germany); Gerard C. van Rhoon (Erasmus MC Cancer Institute, The Netherlands); Desmond Teck Beng Yeo (GE Global Research, USA)
Clinical studies have established that adjuvant mild hyperthermia significantly increases the efficacy of radio- and chemotherapy across many tumor sites. Radiofrequency hyperthermia treatment quality is usually monitored with invasive temperature sensors, which provides limited data sampling and causes infection risks. To mitigate these issues, magnetic resonance (MR) measurements can be exploited for 3D thermal dose assessment during treatment. To this end, a number of novel hardware approaches have been proposed to combine RF heating and imaging more effectively. In this work, we review the status of MR guided radiofrequency hyperthermia, including the electromagnetic inter-systems interactions. We review the various purposes of MR imaging in radiofrequency hyperthermia, and describe different hybrid hardware configurations before closing with suggested technology improvements that could accelerate clinical adoption of this technology.

09:00 ***Development and Clinical Implementation of a Hybrid System Consisting of an MRI and Medical Linear Accelerator***
Teo Stanescu (University of Toronto & Princess Margaret Cancer Centre, Canada)
Development and clinical implementation of a hybrid system consisting of an MRI and medical linear accelerator Development and clinical implementation of a hybrid system consisting of an MRI and medical linear accelerator

09:20 ***A Parasitic Superdirective Electrically Small Coil Array for Magnetic Resonance Imaging***
Xianming Qing and Xinyi Tang (Institute for Infocomm Research, Singapore); Zhi Ning Chen (National University of Singapore, Singapore)
A parasitic superdirective electrically small coil array based on printed loop antenna for magnetic resonance imaging (MRI) applications is presented. The proposed coil array is composed of two coils wherein one of the coils is excited and the other is loaded with a tuning capacitor acting as a director to generate directional near-field distribution. The coils are with identical diameter of 30 mm and are positioned with a distance of 12.5 mm (0.0125 wavelength at 300 MHz). An antenna prototype exhibits directional field distribution and more than 3-dB enhancement of magnetic field intensity compared with a conventional single loop coil antenna with identical size. The proposed directional coil is used as the RF receiving coil for a 7T MRI system, it increases the signal-to-noise ratio (SNR) and penetration level of the system.

09:40 ***A Wireless Power Transfer Route to Magnetically Mediated Hyperthermia***
Hans-Dieter Lang, Gengyu Xu and Costas D Sarris (University of Toronto, Canada)
Hyperthermia therapy is a promising method of cancer treatment, where cancer cells are killed via moderate heat exposure. Magnetically mediated hyperthermia (MMH) is based on the heating of particles or implants, by an externally applied alternating magnetic field. Some MMH systems use induced eddy currents as heat sources. Their operation is very similar to that of wireless power transfer (WPT) systems. Hence, optimization techniques aimed at maximizing the power transfer efficiency of WPT systems can be adapted to optimize heating efficiency in MMH. This paper provides the theoretical framework of this new route to designing MMH systems and analytical results for their optimal heating efficiency. Full-wave electromagnetic simulations further demonstrate the viability of the proposed MMH approach.

10:00 Coffee Break

10:30 ***Multifrequency Approach in Hyperthermia Treatment Planning: Impact of Frequency on SAR Distribution in Head and Neck***
Hana Dobšíček Trefná, Björn Martinsson, Therese Petersson, Niklas Renström, Martin Torstensson and Julia Ravanis (Chalmers University of Technology, Sweden); Petra Kok (AMC

Medical Centrum, The Netherlands); Mikael Persson (Chalmers University of Technology, Sweden)
In this paper we investigated if combination of hyperthermia treatment plans utilizing sequential application of various frequencies is superior to the heating with single frequency settings.

10:50 ***Technological Requirements for Microwave Ablation of Adrenal Masses***
Hojjatollah Fallahi (Kansas State University, USA); Atif Shahzad (National University of Ireland, Galway, Ireland); Daniel Clausing (Kansas State University, USA); Martin O'Halloran (National University of Ireland, Ireland); Michael Dennedy (National University of Ireland Galway, Ireland); Punit Prakash (Kansas State University, USA)
Microwave thermal ablation is under consideration for minimally invasive treatment of bilateral adrenal adenomas, symptomatic of Conn's syndrome. Currently available microwave technologies are ill-suited to precise ablation of small adrenal targets. We report on our preliminary computational and experimental efforts towards the design of microwave ablation systems for targeting adrenal masses. Broadband dielectric properties of ex vivo bovine adrenal glands were experimentally measured. Computer simulations demonstrated the feasibility of achieving precise ablation of adrenal lesions with 2.45 GHz systems. Experiments in ex vivo adrenal tissue using a water-cooled 2.45 GHz antenna illustrated the feasibility of heating 10-20 mm adrenal targets with 40 W power applied for 1 min. These preliminary results warrant further investigation and development of microwave technology for precise ablation of adrenal masses.

11:10 ***TDOA-Based Microwave Imaging Algorithm for Real-Time Monitoring of Microwave Ablation***
Shouhei Kidera (University of Electro-Communications, Japan); Luz Maria Neira, Barry Van Veen and Susan Hagness (University of Wisconsin-Madison, USA)
Microwave ablation (MWA) is widely recognized as a promising treatment tool for cancer. To ensure an effective and safe treatment, real-time monitoring of the dimensions of the ablation zone is indispensable. In this paper, we propose a microwave imaging algorithm for monitoring the evolution of the ablation zone. This algorithm estimates the boundary of the ablation zone by exploiting the time difference of arrival (TDOA) between pre- and during-ablation signals. A notable advantage of this method is that it requires few assumptions about the spatial distribution of dielectric properties of the propagation media. We investigate the performance of this approach using simulated array measurements obtained from FDTD simulations of MRI-derived numerical breast phantoms. The results demonstrate that our proposed method offers the potential to achieve millimeter order accuracy in estimating the boundary of the ablation zone in heterogeneous and dispersive breast tissue.

11:30 ***A Full-Wave Numerical Assessment of Microwave Tomography for Monitoring Cancer Ablation***
Gennaro G. Bellizzi (Mediterranea University of Reggio Calabria & IREA - National Research Council, Italy); Lorenzo Crocco (CNR - National Research Council of Italy, Italy); Marta Cavagnaro and Laura Farina (Sapienza University of Rome, Italy); Vanni Lopresto (ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy); Rosa Scapaticci (CNR-National Research Council of Italy, Italy)
In this communication, we present a full-wave numerical study aimed at showing the potential of microwave tomography as a tool to monitor microwave ablation of solid tumors. The goal is to track the changes in dielectric properties of the tissue undergoing the treatment, in order to appraise the evolving dimension and shape of the thermally ablated area surrounding the applicator. Such an in-line monitoring capability would entail a significant improvement in the therapeutic effectiveness of cancer treatments exploiting microwave ablation, both in terms of optimization/personalization of the therapeutic protocol and of reduction of unwanted side effects due to the unwanted increase of temperature in healthy tissues. The numerical study involves a scenario inspired by an existing experimental set-up, already used for the ex-vivo assessment of microwave ablation treatments. Hence, the promising results we have obtained, fully motivate us to progress towards the experimental demonstration of the concept in ex-vivo conditions.

Friday, March 24, 08:40 - 10:00

H_A03 Array Antennas for Future Applications

TOP

High Data-rate Transfer / Regular Session / Antennas
Oral Sessions: Room 343
Chairs: Mark J. Bentum (University of Twente, The Netherlands), Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

08:40 ***A Dual-Polarized Slotted-Waveguide Antenna Based on Gap Waveguide Technology***
Miguel Ferrando-Rocher (Universidad Politécnica de Valencia, Spain); Ashraf Uz Zaman and Jian Yang (Chalmers University of Technology, Sweden); Alejandro Valero-Nogueira (Universidad Politécnica de Valencia, Spain)
This paper describes a wide-band dual-polarized slotted-waveguide antenna working at V-band (57 - 66 GHz) based on Gap Waveguide concept. The antenna has three layers.The first one (feeding-layer 1) is practically identical to the second one (feeding-layer 2). This optimizes the design and facilitates manufacturing.The corporate-feeding networks on the two layers are rotated 90 degrees to each other to get the two orthogonal

polarizations. Radiating elements are square apertures located on the top of the antenna. Simulated results show both impedance bandwidth and radiation pattern bandwidth greater than 15% for both polarizations.

09:00 ***Development and Validation of Modelling Techniques for Large Periodic Arrays in Ka-band***

Benoit Lesur (Zodiac Data Systems & XLIM Laboratory, France); Amel Maati (University of Limoges & XLIM, France); Marc Thevenot (XLIM-UMR CNRS 7252, University of Limoges, France); Cyrille Menudier (XLIM - UMR CNRS 7252 - University of Limoges & Antennas & Signals, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Christophe Melle, David Chaimbault and Alain Karas (Zodiac Data Systems, France)

This paper presents the design and accurate simulation of two small and medium-sized antenna arrays working in Ka-band (20 GHz). Feeding networks and radiating panels are studied separately and two methods for extracting the scattering matrices of the radiating panels are presented and compared. These developments are an important step of the further modelling of larger arrays.

09:20 ***Grating Lobes Prediction in 3D Array Antennas***

Sjoerd Bosma, Wessel Bruinsma and Robin Hes (Delft University of Technology, The Netherlands); Mark J. Bentum (University of Twente, The Netherlands); Ioan E. Lager (Delft University of Technology, The Netherlands)

This papers discusses an effective framework for determining the number and direction of all possible grating lobes in the case of three-dimensional (3D) array antennas. Illustrating examples support the introduced theoretical concepts. The analysis highlights some intrinsic benefits of using 3D architectures, when compared with planar arrays. It also presents incentives for including the discussion of this class of conceptually relevant systems in (under)graduate curricula.

09:40 ***Control of Phase in Radial Line Slot Antenna for 5G Communications at 60GHz***

Manuel José López Morales (Universidad Politécnica de Madrid, Spain); Jiro Hirokawa (Tokyo Institute of Technology, Japan); Manuel Sierra-Castañer (Universidad Politécnica de Madrid, Spain)

This paper shows the design of a radial line slot antenna for being used in indoor environments in the 60 GHz band of the future 5G communication systems. The antenna is designed to work in near field situation, creating a uniform field in a certain volume, improving the size of this volume with respect the use of uniform phase. The paper analyzes different configurations of phase on the slots and performs the design of the slot position and length on the upper plate of the radial line slot antenna.

TOP

CS03 Addressing Radio Frequency Test Challenges in Diverse Environments (AMTA/EurAAP)

Future Applications / Convened Session / Propagation
Oral Sessions: Room 351
Chairs: Dennis Lewis (Boeing, USA), Janet O'Neil (ETS-Lindgren & TMC China, USA)

08:40 ***The Effect of Receiving Antenna Orientation and Polarization on Measurements of Antenna Efficiency in a Reverberation Chamber***

Tian Hong Loh (UK, National Physical Laboratory, United Kingdom); Jinyuan Li (National Institute of Metrology, P.R. China)

This paper presents a study into the effect of receiving antenna orientation and polarization on the measurement of antenna efficiency for electrically small antennas (ESAs) in a reverberation chamber (RC). Throughout the measurements, the same transmitting antenna was used whereas the receiving antenna was either the antenna under test (AUT) or a reference antenna (REF) of known efficiency. A series of measurements were made for various combinations of AUT and REF antenna orientations and polarizations. The obtained radiation efficiency results are compared. The AUT used for this study was an electrically small dielectric resonator antenna (DRA). The results show that differences in measured efficiency of up to 2 dB (i.e. 40%) can arise due to different AUT and REF orientations and polarizations.

09:00 ***Efficient Broadband Electromagnetic Modeling of Anechoic Chambers***

Zhong Chen (ETS-Lindgren, USA); Zubiao Xiong (ETS-Lindgren, Inc., USA); Ji Chen (University of Houston, USA)

An efficient method is presented to numerically model anechoic chambers ranging from VHF to microwave frequencies. In this method, an approximate image theory is proposed to improve the accuracy of plane wave assumptions used at lower frequencies. At high frequencies, an efficient image-based ray tracing algorithm is developed which integrates with the approximate image theory seamlessly. Numerical results demonstrate the applications in the analysis of anechoic chambers for both low frequency and high frequency ranges.

09:20 ***Measuring the Interaction of Wind Turbines with Terrestrial Navigation and Radar Systems Deploying UAS***

Thorsten Schrader (Physikalisch-Technische Bundesanstalt, Germany); Jochen Bredemeyer (FCS Flight Calibration Services GmbH, Germany); Marius Mihalachi, Jan Rohde and Thomas Kleine-Ostmann (Physikalisch-Technische Bundesanstalt, Germany)

We describe the development of a system for measurements of electromagnetic field strength distributions and on-

site antenna calibrations based on an unmanned aerial system (UAS). The commercially available octocopter was improved by a state-of-the-art GNSS navigation system and a shielding against electromagnetic harsh environments. We have designed, built and tested the FPGA-based data logging hardware as well as several RF frontends and antennas to be mounted on the UAS. We show first applications of our UAS measuring the interaction of wind turbines and terrestrial navigation systems such as DVOR and radar systems used for air traffic surveillance.

09:40 ***Efficient and Novel Test Techniques for the Evaluation of Antenna and Wireless Performance for Large EUTs***

Dennis Lewis (Boeing, USA); Rich Kanemitsu (Keysight, USA)

With the proliferation of wireless electronic devices such as RFID, In-flight Entertainment (IFE) and Personal Electronic Devices (PED) it is important to understand how these systems interact with one another and flight critical systems onboard aircraft. Overall system performance is also of interest due to the varying system performance based on subcomponent installation locations. This paper describes the measurement and evaluation of radio wave propagation inside large commercial aircraft cavities.

Friday, March 24, 08:40 - 11:50

CS28 Near Field Antenna Measurement Techniques (AMTA/EurAAP)

TOP

Radars / Convened Session / Measurements

Oral Sessions: Room 352A

Chairs: Lars Foged (Microwave Vision Italy, Italy), Daniël Janse van Rensburg (NSI-MI Technologies & Nearfield Systems Inc, USA)

08:40 ***A NF/FF Transformation with Spherical Scan for a Noncentred Quasi-Planar Antenna Using a Minimum Number of Data***

Francesco D'Agostino, Flaminio Ferrara, Claudio Gennarelli, Rocco Guerriero and Massimo Migliozzi (University of Salerno, Italy)

An efficient spherical NF/FF transformation for an offset mounted AUT, with a quasi-planar shape, employing a number of NF data minimum and practically equal to that for a centred mounting, is developed. This result has been achieved by applying the nonredundant sampling representation of electromagnetic fields to the voltage collected by the probe and considering the AUT as contained in a double bowl. The interest for this transformation is due to the fact that sometimes an AUT mounting centred on the scanning sphere centre cannot be possible. In such a case, the number of NF data required by the classical NF/FF transformation can remarkably increase, owing to the growth of the minimum sphere radius. In the considered approach, the NF data required by the standard transformation are accurately recovered from the nonredundant ones by employing a 2-D optimal sampling interpolation algorithm. A remarkable measurement time reduction is so obtained.

09:00 ***Prolate Function Expansion of Circularly Supported Aperture Fields in Near-Field Antenna Characterization***

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

We propose a stable and accurate method for the numerical calculation of Prolate Spheroidal Wave Functions (PSWFs) having circular support in both the spatial and spectral domains. Such PSWFs are used to represent the aperture field of circularly shaped aperture antennas and expoited in a Near-Field/Far-Field transformation algorithm. The results show how the quality of the reconstructions can profit of this efficient and effective solution.

09:20 ***Utilizing Partial Knowledge of Phase Differences in Convex Optimization for Amplitude-Only Near-Field Far-Field Transformation***

Alexander Paulus (Technical University of Munich, Germany); Josef Knapp (Technische Universität München, Germany); Thomas F. Eibert (Technical University of Munich (TUM) & Chair of High-Frequency Engineering (HFT), Germany)

Near-field far-field transformations for phaseless antenna measurements suffer from suboptimal solutions due to the lack of information contained in amplitude-only data. Publications on the more general problem of phase retrieval have been able to state conditions on the number of amplitude measurements required for various algorithms to find the globally optimal solution. In this contribution, a possible and practical approach of acquiring the necessary amplitude measurements in terms of phase differences is presented. Simulation and measurement results verify the benefit of phase differences.

09:40 ***Comparative Investigation of Spherical NF Measurements with Full and First Order Probe Correction Using Calibrated or Simulated Probe***

Francesco Saccardi (Microwave Vision Italy, Italy); Andrea Giacomini (Microwave Vision Italy (MVI), Italy); Lars Foged (Microwave Vision Italy, Italy)

Accurate spherical Near-Field antenna measurements are typically performed compensating for the probe pattern during the Near-Field to Far-Field transformation. Depending on the complexity of the probe modal content and on the required accuracy, different Probe Correction (PC) techniques can be applied. It is common practice to distinguish between first order PC, where only $|\mu|=1$ spherical modes of the probe are compensated for, and full PC, taking into account the entire probe spectrum. Another key factor to be considered when applying the PC is the probe characterization. In order to obtain very accurate results, it is common practice to calibrate the probe in dedicated measurement campaigns which, unfortunately, can often be time consuming and expensive.

Alternatively, the simulated probe performance can be used to perform the PC. A comparative investigation between full and first order PC performed using calibrated or simulated probe is presented in this paper.

10:00 Coffee Break

10:30 *Validation of Robotics for Antenna Measurements*

Jeffrey Guerrieri (National Institute of Standards and Technology, USA); David Novotny (US National Institute of Standards and Technology, USA); Joshua Gordon (National Institute of Standards and Technology, USA); Mike Francis (NIST, USA); Alexandra Curtin (National Institute of Standards and Technolgy, USA)

This paper presents recent measurements using the newly developed Configurable Robotic Millimeter-Wave Antenna (CROMMA) facility by the Antenna Metrology Lab at the National Institute of Standards and Technology (NIST). NIST set out to develop an antenna measurement facility that would be reconfigurable to different near-field antenna measurement geometries and perform antenna measurements from 100 to 500 GHz. The positioning capability of the robot has been evaluated and spherical near-field measurements performed at 183 GHz. Spherical far-field and extrapolation measurements have been performed at 112, 118 and 125 GHz. Spherical near-field measurements have been performed at 118 GHz on a CubeSat feed horn and compared to simulated results. Finally, the concept of multi robot antenna measurement facility is discussed.

10:50 *Spherical Near-field Measurement for Probe-fed High Directive Antenna at Millimeter Wave Frequency*

Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Jerome Lanteri (Université Nice Sophia Antipolis, France); Laurent Brochier (Université de Nice-Sophia Antipolis, France); Claire Migliaccio (Université Nice Sophia Antipolis, France); Jean-Yves Dauvignac (Université de Nice-Sophia Antipolis, France)

Accurate measurement of high directive antenna has always been a very challenging topic, especially at millimeter waves (mmW). MmW system are more efficient with a direct connection between the electronic circuits and the antenna. In order to characterize accurately the antenna, RF probe feeding is required and a specific measurement procedure is needed. In this paper, a dedicated set-up is described with near-field measurement capabilities for directive antennas. A 15*15 λ0 reflect array is measured as a proof of example.

11:10 *Wideband Low Weight Probe for Near-Field Antenna Measurements in UHF Band*

Sergiy Pivnenko (Antenna Systems Solutions, Denmark); Beatriz Bedia Exposito (TTI Norte, Spain); Ana Rosa Ruiz (TTI, Spain); Enrique Venero (Antenna Systems Solutions, Spain)

Standard probes for near-field antenna measurements, open-ended waveguides, become bulky and heavy at lower frequencies, below about 2 GHz, that complicates their handling. This paper presents a practical design of a log-periodic dipole antenna (LPDA) specifically developed to possess low level of cross-polarization, to be used as a probe for near-field antenna measurements at frequencies below 2 GHz. The manufactured antenna has low weight and it is easy to handle. The covered frequency band is from 500-1100 MHz, which corresponds to two standard waveguide bands. The antenna can be easily scaled to lower or higher frequencies in the UHF band.

11:30 *Far-Field Pattern and Gain Measurement in Planar Near-Field Techniques*

Serge Balma (CentraleSupélec & Intespace, France); Dominique Picard (DRE, Laboratoire des Signaux et Systèmes, France); Pascal Meisse (Intespace, USA)

This paper presents measurement technique for antenna pattern including gain on planar near field ranges. Although rigorous formalism exists, this formalism is not commonly used due to its complexity. Simplified equations are derived in particular antenna under test (AUT) polarizations and kind of probe corresponding to the most common cases. Application of the technique to a reflector antenna (about 30 dB @ 12 GHz) is described. Analysis of measured results is carried out to illustrate a comparison of accuracy of this technique with results obtained with a compact range.

Friday, March 24, 08:40 - 10:00

CS09 Antenna for IoT Applications

TOP

Localization & Connected Objects / Convened Session / Antennas

Oral Sessions: Room 352B

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

08:40 *A Radiation Efficiency Bound for Small Metallic Antennas*

Carl Pfeiffer (Defense Engineering Corp & Air Force Research Labs, USA)

Bandwidth limitations for small antennas have been thoroughly treated in the past. However, it is the radiation efficiency that dictates the minimum antenna size in many practical scenarios. Here, radiation from a thin metallic shell is analyzed to establish an upper bound on the radiation efficiency of electrically small antennas in terms of the size and the metal skin depth. This fundamental limit provides valuable insight into the design of antennas with optimal efficiencies.

09:00 *Chipless Wireless Displacement Sensor Sensitivity Analysis for IoT Applications*

Ruben Campo, Fatima Villa, Josu Catalina, Lucia Merino and Miguel Sanz (Tecnun Universidad de Navarra, Spain); Daniel Valderas (Ceit and Tecnun, University of Navarra, Spain)

This paper shows a wireless chipless displacement sensor for IoT applications. It is designed for environments where only an on-off position detection is required. The results shows that an oscillation of 30 mm can be detected at a 30 cm distance giving a 10% resolution. Static and dynamic tests demonstrate that the number of oscillations around a certain position can be counted.

09:20 ***Compact Integrated IoT Antenna Robust to the Effects of the Environment***

Thomas Houret (Université Côte D'Azur, CNRS, LEAT, France); Leonardo Lizzi (Université Côte d'Azur, CNRS, LEAT, France); Fabien Ferrero (University Nice Sophia Antipolis, CNRS, LEAT & CREMANT, France); Christophe Danchesi and Stephane Boudaud (Abeeway, France)

In this paper, a reconfigurable antenna integrated into a miniature device for asset tracking is presented. This antenna system has the ability to compensate environment effect by tuning the antenna resonance frequency. The proposed solution is assessed in two different scenarios: in free space and when the device is placed over a metallic surface.

09:40 ***Isolation Enhancement in MIMO Reconfigurable PIFAs for Mobile Devices***

Fatima Al Zahraa Asadallah and Joseph Costantine (American University of Beirut, Lebanon); Youssef Tawk (The University of New Mexico & Notre Dame University Louaize, USA); Christos Christodoulou (The University of New Mexico, USA)

This paper focuses on enhancing multiband isolation between two antenna elements in a reconfigurable multiple input multiple output (MIMO) system. The antennas are reconfigurable printed inverted F antennas (PIFA) that resort to two PIN diodes each to achieve frequency reconfiguration. The isolation between the antenna elements is proposed to be improved through the use of multiple nested slots in the common ground plane between the elements. These slots collectively act as a multi-band reject filter and improve the isolation at the various operational frequencies of the antenna system. The reconfigurable MIMO antenna system is proposed for integration into mobile devices with an operation that covers mobile communication applications.

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R_A03 Defense and Security Applications

Radars / Regular Session / Antennas

Oral Sessions: Room 353

Chairs: Raphael Gillard (IETR & INSA, France), Mario Orefice (Politecnico di Torino, Italy)

08:40 ***Design and Oblique Incidence Performance of a Planar Radome Absorber***

Sofian Hamid (RWTH Aachen, Germany); Hammam Shakhtour (RWTH Aachen University, Germany); Britta Karnbach (Institute of High Frequency Technology RWTH Aachen, Germany); Dirk Heberling (RWTH Aachen University, Germany)

Design and measurement of a planar radome absorber under oblique incidence are presented. The structure is composed of a bandpass multilayers frequency selective surface (FSS) combined with periodic cylindrical-shaped absorbers. This configuration made the resulting structure transparent at the intended antenna operational frequencies (C-band) and absorptive at higher frequencies (X-band). The prototype has been fabricated with a dimension of 24.5 cm × 24.5 cm × 0.65 cm. Performance under oblique incidence (without the antenna) is investigated using NRL arch technique in the absorption band. Reflection less than -10 dB is maintained in the range of 8.5 GHz - 11 GHz up to 40° incidence angle for incoming waves with perpendicular polarization. Under parallel polarization, the -10 dB reflection is achieved up to 50° in the range of 8 GHz - 12 GHz.

09:00 ***Re-consideration of Kirchhoff's Current Law for Electromagnetic Cloaking and Invisibility with Plasmonic Materials or Impedance Metasurfaces***

Giuseppe Labate, Ladislau Matekovits and Mario Orefice (Politecnico di Torino, Italy)

In the present paper, the Kirchhoff's Current Law (KCL) is re-considered as a cloaking condition for structures based on dielectric-plasmonic materials (Plasmonic Cloaking) and devices made up of metallic-dielectric metasurfaces (Mantle Cloaking). Consistently with Devaney-Wolf Theorem III on non-scattering sources, the KCL is derived by imposing zeros on scattered near-fields in the quasi-static limit: beyond the quasi-static regime, the KCL can represent a local condition on each unit cell of impedance metasurfaces. The aim of this paper is to introduce a unified physical-mathematical framework for invisibility and cloaking devices from a novel perspective based on contrast and impedance concepts.

09:20 ***A Switching Mechanism to Mitigate Scan Blindness in Phased Arrays***

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

This paper presents a novel solution to extend the scanning range of a cavity-backed stacked-patch phased array subject to scan blindness. Two main aspects are investigated. The first section is a thorough description of the scan blindness mechanism occurring in the reported array, taking into consideration the characteristics of the associated mutual coupling scheme. The second section introduces a revised array topology that allows extending the scanning range. The proposed solution is based on the switching between two operating modes of the structure, each one covering a distinct scanning range. Taken together, they potentially allow freeing the structure from scan blindness. In the present case, the scanning capability of the array has been extended by 10° in the scanning plane of interest.

09:40 ***Novel High Gain Polarization Switchable Rectangular Slot Antenna for L-band Applications***

Rajesh K Singh (IIT Delhi, India); Ananjan Basu (Indian Institute of Technology, Delhi, India); Shiban K Koul (Indian Institute of Technology Delhi, India)

— A novel high gain polarization switchable rectangular slot antenna is proposed in this paper. Antenna consists of a rectangular slot can be switched in three polarization states; left hand circular polarization (LHCP), linear polarization (LP), and right hand circular polarization (RHCP) by controlling the bias voltage of PIN diodes. The proposed antenna is fabricated on a RT/duroid 5880 substrate. Slots are etched on one side of the substrate, while the microstrip feed network is printed on the other side. A metal reflector is placed in a plane parallel to the slot surface to make radiation pattern unidirectional and hence increase the overall gain of the antenna. Measured results are well matched with the simulated ones. Measured 3dB axial ratio bandwidths for LHCP and RHCP are 125 MHz and 120 MHz, respectively. Measured gain of the antenna is around 7 dB at 1.2 GHz in all three states.

Friday, March 24, 08:40 - 11:50

TOP

CS34 Phased Arrays for Radio Astronomy

Space / Convened Session / Antennas

Oral Sessions: Room 362/363

Chairs: Christophe Craeye (Université Catholique de Louvain, Belgium), David S Prinsloo (ASTRON & Netherlands Institute for Radio Astronomy, The Netherlands)

08:40 ***UAV-based Technique for the Characterization of the Intrinsic Cross-Polarization Ratio (IXR)***

Giuseppe Virone (Consiglio Nazionale delle Ricerche, Italy); Fabio Paonessa (CNR-IEIIT, Italy); Oscar 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); Pietro Bolli (Osservatorio Astrofisico di Arcetri, Italy); Eloy de Lera Acedo (University of Cambridge, United Kingdom)

This paper presents a measurement strategy for the Intrinsic Cross Polarization Ratio (IXR) of Jones polarimeters operating at VHF /UHF bands. It is based on a suitable representation of the Jones matrix which identifies the relevant antenna parameters for IXR evaluation. The same representation is used within a best-fit procedure with experimental results that can be obtained using a rotating UAV-mounted test source.

09:00 ***Expanding the Field of View: Design Considerations for a Sparse-regular FFT SKA Radio Telescope***

Jan Geralt Bij de Vaate (Stellenbosch University); David B Davidson (University of Stellenbosch, South Africa); Pieter Benthem (ASTRON, The Netherlands)

This paper discuses a system approach to fully exploit the potential of phased arrays for radio astronomy: instantaneous (nearly) all sky observations.

09:20 ***Phased Array Feed Development for ASKAP, with the Benefit of Hindsight***

Robert Shaw (CSIRO, Australia)

An overview of ASKAP phased array feed (PAF) development is presented. New analytical and experimental techniques devised for ASKAP are described. Dedicated engineering test facilities are shown to be invaluable for system verification. Experience gained from PAF manufacture is compared with forecasts, and the importance of routine engineering demonstrated.

09:40 ***Numerical Modelling of SKA AA-Mid Tile Configurations Using HARP***

Jens Abraham (Cavendish Laboratory, University of Cambridge, United Kingdom); Ha Bui Van (Université Catholique de Louvain & ICTEAM, Belgium); Eloy de Lera Acedo (University of Cambridge, United Kingdom); Christophe Craeye (Université Catholique de Louvain, Belgium)

The Square Kilometre Array - Aperture Array Mid-frequency instrument will be part of the largest next generation radio telescope. To meet the scientific requirements while maintaining a lower number of antenna elements, the University of Cambridge is developing a sparse random array solution using log-periodic dipole array antennas. In this paper we present the application of HARP, a numerical method based on the Method of Moments capable of simulating very large finite arrays of disconnected antennas, to analyze different sub-array configurations based on 16-element tiles and compare it to a randomized 64 element array.

10:00 Coffee Break

10:30 ***Calculating the Maximum Quantization Scan Error in Dense Phased Arrays***

Jacki Gilmore and Cornelis Wilke (Stellenbosch University, South Africa); David B Davidson (University of Stellenbosch, South Africa)

This paper presents a method with which to calculate the maximum scan error due to phase quantization in the visible region of dense phased arrays. The scan error is expressed as a function of the density ratio and the number of bits being used for digitization. A closed-form expression is derived with which the maximum scan error as well as the maximum scan range in the visible region of the array can be calculated as a function of the number of bits

being used and the density ratio.

10:50 ***Characterization of Disconnected Dense Vivaldi Arrays***

David S Prinsloo (ASTRON, The Netherlands Institute for Radio Astronomy); Mark Ruiter (ASTRON, The Netherlands); Michel Arts (ASTRON, the Netherlands Institute for Radio Astronomy, The Netherlands)

The effect of implementing spacing between adjacent Vivaldi antenna tiles within a dense station layout is investigated. Considering the maximum side lobe level of a dense connected Vivaldi antenna array operating at a frequency and scan angle where a grating lobe is generated in the visible region, it is shown that introducing a separation between the constituent station tiles results in an initial reduction in the grating lobe level of approximately 8 dB. Further mitigation of the dispersed grating lobe power is demonstrated by solving the tied-array beam of 18 disconnected dense Vivaldi antenna stations rotated by 10 degrees with respect to each other.

11:10 ***Graphene Based Cross Ring Antenna Array with Electromagnetic Band Gap Structures***

David Zhang, Anthony Keith Brown and Ming Yang (University of Manchester, United Kingdom); Ahmed El-Makadema (The University of Manchester, United Kingdom)

Crossed Ring Antenna is using a 2-D planar structure design to form low cost aperture arrays. However, using the conventional PCB based conducting materials to build the radiating or receiving antenna surfaces for large scale applications, such as Square Kilometre Array, is still costly. 2-D material like printed graphene implemented by forming conductive ink with graphene nanoflakes can be a promising solution. It is superior for conformal structures and can be processed at low temperature, therefore low cost substrate such as textile, paper can be used for printing. On the other hand, mono or few layers of graphene is a moderate to bad conductive surface in the mm-waves and lower frequency. Electromagnetic Band Gap structures made from Graphene can be inserted perpendicularly to the antenna surface to absorb the waves potentially to produce the common modes.

11:30 ***Failure Identification and Pattern Correction in Large Isophoric Sparse Arrays***

Daniele Pinchera and Marco Donald Migliore (University of Cassino, Italy)

The aim of this contribution is to discuss the application of a failure detection and sparse recovery technique to a very large isophoric sparse array proposed for satellite communications. Accurate numerical results will show that the sparsity of the source is beneficial to the failure detection process, and a limited number of sensor can be used for the online detection of the failures and correction of the pattern without interfering with the normal array operation.

Friday, March 24, 10:30 - 11:50

F_A08 Leaky-Wave Antennas

TOP

Future Applications / Regular Session / Antennas

Oral Sessions: Room 341

Chairs: Janusz Grzyb (University of Wuppertal, Germany), Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

10:30 ***A TM0 Surface Wave Launcher by Microstrip and Substrate Integrated Waveguide Technology***

Victoria Gómez-Guillamón Buendía, Symon K. Podilchak and George Goussetis (Heriot-Watt University, United Kingdom); Jose-Luis Gómez-Tornero (Polytechnic University of Cartagena, Spain)

A surface wave launcher in substrate integrated waveguide technology is proposed. The launcher utilizes a conventional microstrip to SIW transition with the motivation of transferring power into the dominant TM0 surface wave mode of a grounded dielectric slab. Moreover, by appropriate design of the SIW section and by applying field matching techniques using sub-wavelength microstrip patches while also conveniently separating some of the via conducting posts for one of the SIW side-walls, energy can leak into the GDS with minimal losses for the generation of a bound and guided TM SW plane-wave with a uniform phase front. Our new approach for simple, microstrip-fed SW launching at microwave frequencies can be useful for other SW-based guides, novel low-cost transitions, and new compact dividing/combing circuits for antenna feed systems as well as other SW structures which employ a common substrate.

10:50 ***Bessel Beam Generation by Means of Annular Leaky-Wave Antennas***

Davide Comite, Walter Fuscaldo, Paolo Burghignoli and Paolo Baccarelli (Sapienza University of Rome, Italy); Symon K. Podilchak (Heriot-Watt University, United Kingdom); Alessandro Galli (Sapienza University of Rome, Italy)

The possibility to generate a nondiffracting Bessel beam by means of a fast backward spatial harmonic supported by an annular metal-strip grating placed on a grounded dielectric slab is demonstrated. The focusing capabilities of the relevant leaky-wave aperture field are investigated in conjunction with the dispersive analysis of the considered structure. Full-wave simulations of a prototype are developed using a commercial code. The proposed design represents an attractive simple and low-cost solution potentially able to generate an arbitrary-order nondiffracting beam.

11:10 ***Wideband Omnidirectional Planar Antenna with Vertical Polarization***

Lei Wang and Lars Jonsson (KTH Royal Institute of Technology, Sweden); Juan R Mosig (Ecole Polytechnique Federale de Lausanne, Switzerland)

In this paper we propose a circular leaky wave-antenna with omnidirectional radiation pattern in the H-plane. The design utilizes double-layered strips to create an end-fire antenna. A linear tapering of the stripes in the design endows the antenna with a 27% impedance bandwidth of 26.4-34.6 GHz. The antenna is vertically polarized with a cross polarization below -30 dB. The antenna has low gain variation in H-plane and it is compact as a planar structure. Furthermore, it can be easily fabricated and integrated by common PCB processing, which is very promising for applications such as base stations for wireless communication, spectrum monitoring and jamming systems.

11:30 ***Leaky-Wave Antenna in Planar Technology with High Directivity in the Transverse Plane***

Alejandro Javier Martinez-Ros (Universidad de Sevilla, Spain); Maurizio Bozzi and Marco Pasian (University of Pavia, Italy); Francisco Mesa (Universidad de Sevilla)

A leaky-wave antenna (LWA) designed in substrate integrated waveguide (SIW) technology and showing high directivity in its transverse plane is presented. In addition, the proposed SIW LWA allows for the flexible control of its complex propagation constant, and thus of its radiation properties. For this purpose, the width of the SIW is used for the control of the phase constant and the separation between posts for the leakage rate. Moreover, the proposed structure works with the TE20 mode of the SIW, which makes it possible the radiated electric fields be added in phase at the center of the SIW, providing higher directivity in the transverse plane compared to single line-source antennas. Full-wave simulations are given to support the theoretical concepts exposed along the work. Furthermore, several prototypes have been designed at the frequency of 15 GHz to validate this work.

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F_P02 Other Propagation Topics

Future Applications / Regular Session / Propagation

Oral Sessions: Room 343

Chairs: Giuseppe Torrisi (INFN-LNS, Italy), Alenka Zajic (Georgia Institute of Technology, USA)

10:30 ***Ship-to-Ship Broadband Channel Measurement at 5.2 GHz on North Sea***

Wei Wang, Thomas Jost, Ronald Raulefs and Uwe-Carsten G. Fiebig (German Aerospace Center (DLR), Germany)

A broadband channel sounder measurement campaign was conducted to investigate the ship-to-ship propagation channel in the C-band at 5.2GHz with a signal of 120MHz bandwidth. This paper presents details of the measurement campaign. Two scenarios with two vessels in rough sea conditions that either follow or drive towards each other are presented. First results in terms of power delay profile and delay Doppler spectrum are presented.

10:50 ***Path Loss Prediction for Electromagnetic Side-Channel Signals***

Alenka Zajic, Milos Prvulovic and Derrick Chu (Georgia Institute of Technology, USA)

This paper investigates propagation mechanisms that EM side-channel signals experience at different frequencies and proposes models for near-field and far-field propagation of side-channel signals. The near-field propagation is modelled as a field created by an electric monopole (Hertzian dipole) and a magnetic dipole, where the received power is collected using only magnetic components of the EM field. This model resulted in excellent match with measured data. Furthermore, this paper investigates unintentionally modulated side-channel signals. The propagation of EM side-channel signals was modelled using free space propagation model which resulted in excellent match with measured data. In both cases we have observed that signal can be received at several meters from the side-channel source. The proposed models are the first step in understanding propagation mechanisms of EM side-channel signals and how to predict the distance at which they can be received.

11:10 ***Study of Electromagnetic Field Propagation in Microwave-Heated Magnetoplasmas of Compact Ion Sources***

Giuseppe Torrisi, David Mascali, Gino Sorbello, Lorenzo Neri, Luigi Celona, Giuseppe Castro, Ornella Leonardi and Santo Gammino (INFN-LNS, Italy)

This paper presents the study of electromagnetic wave propagation in anisotropic, lossy and strongly inhomogeneous magnetoplasmas of compact ECR-type ion sources. Due to the specific shape of the magnetostatic field (B-minimum configuration), no simple symmetries can be assumed: a 3D approach is then mandatory. The operating wavelength is comparable with cavity length ($\lambda_{RF}\sim L_{c}$), hence the ``resonator'' effect of the metallic cylindrical cavity where the plasma itself is sustained by the microwaves cannot be neglected. In addition, the characteristic lengths of plasma parameters are often smaller than the wavelength, thus implying a full-wave approach in modeling and simulations. These plasmas have to be described by lossy spatially dispersive ``hot'' ($v_\phi\sim v_{th}$) dielectric tensor in order to model the inner plasma modes conversion and plasma-waves. The paper describes in details the modeling strategy for both microwave-to-plasma coupling schemes and for advanced, microwave based diagnostics tools such as interferometry and polarimetry.

11:30 ***Ionospheric Propagation Monitoring and TEC Measurements Using GPStation-6 GNSS Receiver***

Andra Pastrav (Technical University of Cluj-Napoca, Romania); Emanuel Puschita (Technical University of Cluj-Napoca & Control Data Systems SRL, Romania); Tudor P Palade (Technical University of Cluj-Napoca, Romania)

NVIS communication solutions are known to be reliable and quickly deployable, but modeling a suitable radio link requires a good prediction of the ionosphere behavior and insights regarding ionospheric propagation. Within the

framework of the SIRIUS project, the Technical University of Cluj-Napoca has acquired, installed, and employed the NovAtel GPStation-6 GNSS receiver for ionospheric scintillation and TEC monitoring. The measured parameters are to be used in the development of ionospheric propagation models for HF transmissions in Eastern Europe. This paper presents the GNSS receiver and its employment for monitoring radio wave propagation through the ionosphere, as well as measuring the electronic density.

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F_A01 Metasurfaces II

Future Applications / Regular Session / Antennas
Oral Sessions: Room 351
Chairs: Daniele Cavallo (Delft University of Technology, The Netherlands), Diego Correas Serrano (University of California, Davis, USA)

10:30 ***Analysis of Artificial Dielectrics Composed of Non-Aligned Layers***
Daniele Cavallo and Cantika Felita (Delft University of Technology, The Netherlands)
In this work, we present an analysis of artificial dielectric layers (ADLs), when a lateral shift between layers is present. The alternate lateral displacement of the layers is an important parameter to engineer the desired effective electromagnetic properties of the ADL material. More specifically, much higher equivalent dielectric constants can be realized by alternatively shifting the layers, compared to the aligned case. Closed-form expressions are given for the equivalent layer reactance that include the higher-order interaction between shifted layers. These analytical formulas are of great aid to design artificial dielectric slabs, as they provide the scattering parameters for generic plane-wave incidence. The effective permittivity and permeability tensors of the artificial dielectrics can then be retrieved from the scattering parameters.

10:50 ***Ultrafast Beam Steering Based on Graphene Metamaterial***
Bakhtiyar Orazbayev and Miguel Beruete (Universidad Publica de Navarra, Spain); Irina Khromova (King's College London)
In this work we demonstrate three different designs of tunable mid-infrared (MIR) beam steering devices based on multilayer graphene-dielectric metamaterials. In all designs the tunable beam steering is achieved by controlling the effective refractive index of the graphene metamaterial, which is done by changing the chemical potential of each graphene layer. The proposed beam steerer concepts allow a wide range of output angles (up to approximately 70 deg) and low reflection losses. The graphene-based tunable beam steering can be used in tunable transmitter/receiver modules for infrared imaging and sensing.

11:10 ***Opportunities in Phosphorene Plasmonic Metasurfaces***
Diego Correas Serrano and Juan Sebastián Gomez-Diaz (University of California, Davis, USA); Alejandro Alvarez-Melcon (Technical University of Cartagena, Spain); Andrea Alù (The University of Texas at Austin, USA)
We investigate the use of black phosphorus thin films in infrared plasmonics and discuss spatial dispersion effects. For appropriate film thickness, black phosphorus exhibits a moderate bandgap suitable for operation in this frequency band, and the intrinsic anisotropy of its conductivity tensor provides exciting possibilities in metasurfaces/reflectarray design, such as polarization-dependent devices and unusual topological transitions for plasmons induced by electrical or mechanical bias. We study the limits on plasmon confinement and field enhancement imposed by spatial dispersion and demonstrate that these bounds are looser than in graphene. These findings may lead to infrared plasmonic devices enabling light-matter interactions beyond the capabilities of other plasmonic materials, with exciting applications in sensing, thermal imaging, and heat scavenging.

11:30 ***Comparison of Circular, Square Cell and Hexagonal Cell Artificial Magnetic Conductors for Broadband Staggered Dipole Arrays with Low Profile***
Halim Boutayeb and Paul Watson (Huawei Technologies, Canada)
Different configurations of the periodic structure for an Artificial Magnetic Conductor (AMC) are analyzed and compared: circular AMC, AMC with square cell and AMC with hexagonal cell. These structures are used for lowering the profile of a dipole and for reducing the coupling between antenna elements in an array. A particular attention is made on the impedance bandwidth in order to satisfy an operation in the band 3.4-3.8GHz (11%). In addition, the cross-polarized radiation field needs to be as low as possible in the array environment. In this work, a novel design for circular AMC is proposed and tested successfully.

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CS49 Wireless Chipless Sensors

Localization & Connected Objects / Convened Session / Antennas
Oral Sessions: Room 352B
Chairs: Simone Genovesi (University of Pisa, Italy), Smail Tedjini (Grenoble-inp, France)

10:30 ***Design of Passive Chipless Wireless Motion Sensor Using Dual Polarization Effect***
Hatem El Matbouly (University of Grenoble Alpes, LCIS, France); Konstantinos Zannas (LCIS, Grenoble-INP, Université Grenoble-Alpes, France); Yvan Duroc (University Claude-Bernard Lyon 1, France)

This paper presents a new principle of a passive chipless RFID wireless sensor for a rotational motion measurement and identification. The sensing and identification principles are based on a high quality factor substrate integrated cavity (SIW) resonator with dual antennas at two different angles. Depending on the angle difference between the dual antennas, the backscattered power generates a unique and identifiable pattern, which encodes in time domain both the rotational speed and the signature code of the rotating object. By the utilization of different dual polarizations, different sensor tags can be created with identification capabilities allow to distinguish between different sensors. The sensor operation principle has been investigated experimentally for determining maximum number of possible codes using the response time of the reader. The choice of SIW for proposed sensor has the advantages of having Q factor and low insertion loss as well as compatibility with planar microwave circuit technology.

10:50 ***Dielectric Ring Resonators as Chipless Temperature Sensors for Wireless Machine Tool Monitoring***

Christian Mandel, Alejandro Jiménez-Sáez and Ersin Polat (Technische Universität Darmstadt, Germany); Martin Schüßler (TU Darmstadt, Germany); Bernd Kubina, Timo Scherer and Nils Lautenschläger (Technische Universität Darmstadt, Germany); Rolf Jakoby (Institute for Microwave Engineering and Photonics, Technische Universität Darmstadt, Germany)

Temperature monitoring of tools is one key method for the prediction and detection of tool failure to prevent damage of valuable workpieces, e. g. in aircraft manufacturing. Therefore, a chipless wireless dielectric temperature sensor for machine tools, with very high temperature capability and compatibility to the harsh machine tool environment, is investigated. Based on these findings, a demonstrator is introduced that is characterized in the lab and tested in a real machine tool. The paper focuses on real world challenges of the sensor system implementation.

11:10 ***Progress in Green Chipless RFID Sensors***

Filippo Costa (University of Pisa, Italy); Etienne Perret (Grenoble INP - LCIS, France); Simone Genovesi (University of Pisa, Italy); Smail Tedjini (Grenoble-inp, France); Antonio Lazaro (URV, Spain); David Girbau and Ramon Villarino (Universitat Rovira i Virgili, Spain); Michele Borgese and Francesco Alessio Dicandia (Università di Pisa, Italy); Giuliano Manara (University of Pisa, Italy)

The challenge in designing chipless RFID sensors is to obtain a reliable and replicable estimation of environmental parameters. The aim of this work is to investigate two promising chipless RFID sensor configurations able to face these challenges.

11:30 ***Towards Multi-Bit, Long Range and Eco-Friendly Implementation of Tag Sensors***

Luca Roselli, Valentina Palazzi, Federico Alimenti and Paolo Mezzanotte (University of Perugia, Italy)

Internet of Things (IoT) is becoming a driving paradigm for the Information and Communication Technology (ICT) evolution. Beyond the well known sensing and communication features that must equip objects to become smart and thus to insert them into IoT world, energy autonomy and the largest compatibility with hosting objects must be pursued. Chipless sensor tags are one of the most promising solution to cope with all these features concurrently, since they are passive and can be easily implementable by using eco-friendly materials. The main limit of classic chipless architectures, however, is that they are usually static and in any case sensing information can be recovered only in presence of a stationary environment. This paper presents a review of some "multi-bit" sensor tag architectures based on the harmonic radar principle that can overcome this limitation and thus be profitably used to support the massive deployment of IoT devices.

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CS35 Polarimetric Radar Signal Processing and RCS Analysis

Radars / Convened Session / Propagation

Oral Sessions: Room 353

Chairs: Dirk Heberling (RWTH Aachen University, Germany), Matthias Röding (Ilmenau University of Technology, Germany)

10:30 ***Fully Polarimetric Wideband RCS Measurements for Small Drones***

Matthias Röding and Gerd Sommerkorn (Ilmenau University of Technology, Germany); Stephan Haefner (Technische Universität Ilmenau, Germany); Robert Müller (TU Ilmenau, Germany); Reiner S. Thomä (Ilmenau University of Technology, Germany); Jan Goerlich and Konrad Garhammer (Saab Medav Technologies GmbH, Germany)

Localization and identification of small unmanned aircraft systems become more and more of interest. In this context radar cross sections for such objects have been investigated by extensive measurements utilizing a fully polarimetric, bi-static wideband mm-wave radar system. The influence of the shapes and orientations of the drones, and of the bi-static angles of the measurement system setup are compared and discussed.

10:50 ***Radar Polarimetry with Interleaved Dual-Orthogonal and Time-Multiplexed Signals: The PARSAX Radar Setup and Preliminary Results***

Sharef Neemat, Oleg Krasnov and Etienne Goossens (Delft University of Technology, The Netherlands); Alexander Yarovoy (TU Delft, The Netherlands)

Radars capable of measuring targets' polarimetric characteristics provide valuable supplementary information for a more reliable detection, identification and physical parameters estimation. The novelty of this work lies in that it

had not been previously possible to perform measurements for a comparison of polarimetric orthogonal simultaneous vs time-multiplexed sequential sounding signals in real-time, because of the time delay required to reconfigure a system to cater for the different waveform types. During this time delay, an observed non-stable target(s) would have had substantially moved, yielding both measurements not directly comparable. In this paper we present the polarimetric interleaved simultaneous-time-multiplexed waveform, justifications for the PARSAX radar setup upgrade, and the system implementation with a focus on the receiver FPGA. Preliminary results from the comparison are revealed. The data and results will be used for a future detailed comparative analysis of sounding waveforms and their impact on polarimetric target characteristics

11:10 ***Polarimetric EM Simulation of Dielectric Radar Benchmark Targets***

Frank Weinmann (Fraunhofer FHR, Germany)

This paper studies the accuracy and limitations of different electromagnetic (EM) simulation approaches for dielectric radar benchmark targets. In comparison to perfect electric conductors (PEC), dielectric targets are much more complex from an EM point of view. However, dielectric materials are widely used for modern aircraft and unmanned aerial vehicles (UAVs). Apart from that, EM simulation tools nowadays play an important role in the design of aerial vehicles and radar systems. In order to evaluate the accuracy and performance of different EM simulation approaches, the results obtained using Physical Optics in combination with a ray tracing approach are compared to full-wave reference data.

11:30 ***A Tomographic Approach to Polarimetric Radar Cross-Section Imaging***

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

Three-dimensional radar cross-section (RCS) images are a valuable support for understanding the scattering events occurring at a radar target. Traditional RCS measurement methods require a large angular range and many measurement points to provide sufficient resolution and unambiguousness. This paper proposes the usage of high resolution techniques, enabled by taking the polarimetric signal components into account. Therefore, the geometry of a compact antenna test range is explained and integrated into a signal model similar to the one of the direction of arrival (DOA) problem. Subsequently, a choice of prominent DOA algorithms are adapted and analyzed according to their tomographic RCS imaging performance. The validation of this approach is done by measuring a reference target's three-dimensional RCS. A comparison of the results of the conventional Bartlett-Beamformer to high resolution methods like Multiple Signal Classification (MuSiC) and Deterministic Maximum Likelihood (DML) is provided in the end, constituting the advantages of MuSiC.

Friday, March 24, 12:00 - 13:00

Closing Ceremony TOP

Room: Oral Sessions: Auditorium Bordeaux

Chairs: Cyril Mangenot (European Space Agency, The Netherlands), Alain Sibille (Telecom ParisTech, France)