Time	C3.3	C3.4	C3.5	C3.6	Online Room A	Online Room B
Monday, October 31						
09:00-09:30		*Opening*				
09:30-10:20		KS1: *Keynote session 1*				
10:20-10:50	Morning Tea					
10:50-12:30		KS2: *Keynote session 2*				
12:30-13:50	Lunch					
13:50-15:30	AS1: *Student Award Competition Session 1*	RS1: *Electromagnetic-Wave Theory and Optimization Problems*	RS2: *Reconfigurable Antennas*	AS2: *ECR Award Competition Session*	OCS1: *Antennas and Circuits/Systems for Millimeter-Wave/Terahertz Applications*	
15:30-16:00	Afternoon Tea					
16:00-17:40	AS3: *Student Award Competition Session 2*	RS3: *3D printing*	RS4: *Energy Harvesting and Wireless Power Transfer*	WS: *Workshop: Stand on the IEEE Antennas and Propagation Standards*	OCS2: *Multifunctional Antennas Inspired by Novel Materials and Methods*	
18:00-20:00	Welcome Reception (C3 foyer)					
Tuesday, November 1						
08:30-10:10	CS1: *Technological advancement in antennas and measurement: Present and future in South Korea*	RS5: *Filters and Filtering Antennas*	RS6: *Lenses*	CS2: *EurAAP Special Session*		
10:10-10:35	Morning tea					
10:35-12:40	IS1: *Invited talk session 1 : Metasurface, Beam Forming and Antenna Measurement*			IS2: *Invited talk session 2: Antennas for Medical, Mobile and Base Station Applications*		
12:40-14:00	Lunch					
14:00-15:40	CS3-I: *Recent advances in array antenna and metasurface engineering (Part I)*	RS7: *Conformal and Flexible Antennas*	RS8: *Indoor and Outdoor Propagation*	CS4: *ASEAN research on Antenna and propagation for 5G Application*	OCS3: *Compact and high-performance planar antennas and their arrays*	OCS4: *Advanced Research and Development of Dielectric Components*
15:40-16:10	Afternoon tea					
16:10-17:50	CS3-II: *Recent advances in array antenna and metasurface engineering (Part II)*	RS9: *Decoupling and Inteference Suppression*	RS10: *Inverse Scattering and Imaging Techniques*	CS5: *Antenna Technology for Cellular and Satellite Communications*	OCS5: *Planar Millimeter-Wave Antenna Arrays for Emerging Applications*	OS1: *MIMO*
Wednesday, November 2						
08:30-10:10	CS6: *Emerging Metasurface Technologies for Antenna Applications*	RS11: *Localization and Remote Sensing*	RS12: *Antennas for Medical Applications*	CS9-I: *Latest Technologies for advanced antenna and measurement systems (Part I)*		
10:10-10:35	Morning Tea					
10:35-12:40	IS3: *Invited talk session 3 : Advanced Electromagnetic Techniques*			IS4: *Invited talk session 4 : Metasurface and Beamforming Techniques*		
12:40-14:00	Lunch					
14:00-15:40	CS7: *Advances in Computational electromagnetics and its application*	RS13: *V2X and IoT*	RS14: *Antennas for Satellite Communications*	CS9-II: *Latest Technologies for advanced antenna and measurement systems (Part II)*	OS2: *Sensing and Imaging*	OS3: *Reflection/Transmission Arrays*
15:40-16:10	Afternoon Tea					

16:10-17:50	CS8: *mm-wave and THz-wave antennas*	RS15: *Reflectarrays*	RS16: *Sensors*	CS9-III: *Latest Technologies for advanced antenna and measurement systems (Part III)*	OS4: *Beamforming*	OS5: *Radars*
18:30-21:30	Banquet and Awards Ceremony					
Thursday, November 3						
08:30-10:10	CS10: *Recent Developments for Multifunctional and Innovative Antenna Technologies*	RS17: *Polarization Related Techniques*	RS18: *Antenna Feed Networks*	CS11: *Advanced Antenna Arrays and Multibeam Scanning Systems*		
10:10-10:40	Morning Tea *Morning Tea*					
10:40-12:20	CS12: *Multi-functional and Wideband Metasurface Antennas*	RS19: *Bandwidth Enhancement Techniques and Wideband Antennas*	RS20: *Antenna Designs*	RS21: *Machine learning and artificial intelligence for AP*	OS6: *New Transmission Lines/Structures*	
12:20-13:40	Lunch					
13:40-15:20	RS22: *Antenna System Measurement and Calibration*	RS23: *Antenna Systems for 5G, B5G and 6G*	RS24: *Propagation Measurement*	RS25: *Gain Enhancement Techniques and High Gain Antennas*	OS7: *Absorbers*	
15:20-15:50	Afternoon Tea					
15:50-17:30	RS26: *mm-Wave and THz Technologies*	RS27: *Investigation of New Materials and Measurement of Particular Antenna Characteristics*	RS28: *Analytical and Computational Methods*	RS29: *Waveguides and Waveguide-Based Antennas*		

Monday, October 31

Monday, October 31 9:00 - 9:30 (Australia/Sydney)

Opening

Rooms: C3.4, C3.5

Chair: Peiyuan Qin (University of Technology Sydney, Australia)

Honorary Chair -- Prof. Andrew Parfitt, University of Technology Sydney

General Chair -- Prof. Y. Jay Guo, University of Technology Sydney

TPC Chair -- Prof. Christophe Fumeaux, The University of Adelaide

Monday, October 31 9:30 - 10:20 (Australia/Sydney)

KS1: Keynote session 1

Rooms: C3.4, C3.5

Chair: Richard W Ziolkowski (IEEE, USA)

Plenary Talk 1

Title: A New Generation of Metasurface Antennas

Speaker: Prof. Stefano Maci, University of Siena, Italy

Abstract: "Metasurface" (MTS) denotes a surface constituted at microwave frequency by PCB or 3D printed elements small in terms of wavelengths that collectively exhibits equivalent homogeneous boundary conditions to any interacting electromagnetic fields. MTSs have had and are having a strong impact in Antenna applications. In the years 2000-2010 MTS for antennas were essentially uniform in space and realized by periodic printed elements. This was the first generation of MTS. In the second generation (2010-2020), MTS for antennas was constructed in such a way to change boundary conditions in space and control the scattered field. Today we are facing a transition to the third generation of MTS antennas, where MTSs change boundary conditions in space and time, opening new perspectives in 5G communications and beyond. In this presentation, the evolution of MTS antennas is described, with new ideas and examples on future communication scenarios.

Monday, October 31 10:20 - 10:50 (Australia/Sydney)

Morning Tea

Monday, October 31 10:50 - 12:30 (Australia/Sydney)

KS2: Keynote session 2

Rooms: C3.4, C3.5

Chair: Richard W Ziolkowski (IEEE, USA)

Plenary Talk 2

Title: Advances in Computational and Experimental Bioelectromagnetics for Healthcare: Sensors and Neurointerfaces

Speaker: Prof. Gianluca Lazzi, University of Southern California, USA

Abstract: Although technical challenges are still daunting, the clinical utility of neuroprosthetics has increased dramatically over the past few years. This has been accomplished through the convergence of numerous disciplines, which have individually added fundamental understanding/capabilities to systems that interface with the human body to restore senses and movement, or treat prevalent diseases that have currently no foreseeable cure. Among these, predictive multiscale computational modeling methods have greatly aided in the design of neuroprosthetics by embracing the complexity of the nervous system, which span multiple spatial scales, temporal scales, and disciplines. In this talk, we will cover some of the recent advances in bioelectromagnetic systems for healthcare, with a particular focus on visual and hippocampal prosthesis, peripheral neuroprosthetics, and sensors.

Plenary Talk 3

Title: New Trends in Antenna Design using Gap Waveguide Technology

Speaker: Prof. Eva Rajo-Iglesias, University Carlos III of Madrid, Spain

Abstract: In this talk, a brief overview of the fundamentals of gap waveguide technology and a summary of classical designs of directive antennas based on corporate fed arrays will be first presented. After that, some new options for using this technology in the millimeter frequency bands will be presented. This includes the use of alternative periodic structures instead of the classical bed of nails, as well as the potential of this technology to be combined with classical technologies such as microstrip and the design of other kind of antennas as for instance leaky wave antennas. In this way, an overview of different on-going research lines connected to this technology will be presented.

Monday, October 31 12:30 - 13:50 (Australia/Sydney)

Lunch

Monday, October 31 13:50 - 15:30 (Australia/Sydney)

AS1: Student Award Competition Session 1

Room: C3.3

Chair: Stephanie Smith (CSIRO & Astronomy and Space Science, Australia)

13:50 ***Ku-Band Metallic Metasurfaces for High-Power Microwave Applications***

Foez Ahmed (University of Technology Sydney, Australia); Khushboo Singh (University of Technology Sydney, Australia & Macquarie University, Australia); Touseef Hayat (Macquarie University, Australia); Muhammad Usman Afzal (School of Electrical and Data Engineering University of Technology Sydney, Australia); Karu Esselle (University of Technology Sydney, Australia)

Metallic metasurfaces operating at Ku-band and suitable for high-power microwave applications are presented. They are made of cheap off-the-shelf metal sheets and synthesized based on the near-field phase transformation principle. Two pairs of non-uniform slots are etched in the center of the thin metal sheet, and such identical layers are stacked to form the phaseshifting cell. Slots' lengths can control the full 360° phase range with high transmission efficiency. Cells are strategically arranged to form the near-field phase transforming metasurfaces (NFPTMs). They are innovatively applied to enhance the antenna gain by two-fold and steer the antenna beam within the 104° large conical space. In addition, the proposed NF-PTMs have a power handling capability of 1.9 GW level.

14:10 ***Doppler Velocity Decomposed Radar Imaging Method for 79 GHz Band Millimeter Wave Radar***

Yoshiki Sekigawa (The University of Electro-Communications, Japan); Shouhei Kidera (University of Electro-Communications, Japan)

Millimeter Wave (MMW) radar is promising for tar- get identification in short range sensing scenario. In particular, 79 GHz band multiple-output-multiple-input (MIMO) MMW radar has numerous advantages, in terms of high spatial resolution and compact module. However, in the case of complicated shape object, such as human body, it suffers from insufficient spatial resolution. Thus, this paper introduces the Doppler velocity decomposed radar imaging method, focusing on moving objects with different velocity, such as walking human. The experimental test, using 79 GHz MMW band radar, demonstrate that our proposed method retains a sufficient spatial resolution in multiple moving objects.

14:30 ***Azimuth and Elevation Scanning With Stacked Modulated Geodesic Luneburg Lenses***

Pilar Castillo-Tapia and Oskar Zetterstrom (KTH Royal Institute of Technology, Sweden); Astrid Algaba-Brazález (Ericsson AB, Sweden); Lars Manholm and Martin Johansson (Ericsson Research, Sweden); Nelson Fonseca (European Space Agency, The Netherlands); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

Here, we propose a modulated geodesic lens antenna array in E-band (56-62 GHz), which has scanning abilities in both azimuth and elevation. The array consists of four lens antenna elements, and each lens antenna produces 13 independent beams that cover 110 degrees in the H-plane with scan losses below -1 dB. The array is fed with a 1:4 power divider comprising three phase shifters to scan in the E-plane. The distance between lenses in the E-plane is 0.7 wavelengths at 60 GHz. The E-plane coverage is 60 degrees with scan losses around -2.2 dB. The maximum realized gain varies from 20.8 to 24.1 dB across the frequency band.

14:50 ***Modular Wearable Textile Antenna With Pattern-Interchangeability Using Snap-On Buttons***

Quoc Hung Dang (The University of Adelaide & Australia, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

A dual-band wearable textile patch antenna with modular pattern interchangeability is proposed in this paper. The antenna simultaneously covers the 2.45 and 5.8 GHz Industrial, Scientific and Medical (ISM) radio bands. By utilizing detachable shorting connections made of metallic snap-on buttons, the proposed antenna can be set up to operate either with broadside or omnidirectional radiation patterns at 2.45 GHz, while the radiation characteristics at 5.8 GHz remain unchanged. The proposed modular antenna is fabricated and measured to

validate the concept.

15:10 ***Full Azimuthal Coverage in Planar Lens Antennas***

Freysteinn Vidar Vidarsson and Oskar Zetterstrom (KTH Royal Institute of Technology, Sweden); Astrid Algaba-Brazález (Ericsson AB, Sweden); Lars Manholm and Martin Johansson (Ericsson Research, Sweden); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This paper describes the design of a generalized Luneburg lens antenna that can scan 360° in azimuth. The full azimuth scanning is achieved by deploying two identically stacked lenses and 3 dB 90° hybrid couplers. The antenna operates in the n260 band, from 37-40 GHz. Simulation results of the integrated antenna system are presented illustrating that the antenna can scan 360° in the azimuth plane.

AS2: ECR Award Competition Session

Room: C3.6

Chair: Rodica Ramer (University of New South Wales, Australia)

13:50 ***High Gain Filtering Lens Antenna***

Hossein Sarbandi Farahani and Behrooz Rezaee (Graz University of Technology, Austria); Wolfgang Bosch (Graz University of Technology & Institute of Microwave and Photonic Engineering, Austria)

In this paper, a Ka-band high gain filtering antenna (Filtenna) based on distributed coupled-resonators and 3D-printed dielectric lens is investigated. The substrate integrated cavity (SIC) coupled-resonators and cavity-backed patch antennas are effectively employed to form a 2 × 2-array Filtenna loaded by a dielectric lens. The proposed lens Filtenna with fourth-degree Chebyshev filtering response centered at 31 GHz, bandwidth of 2 GHz, return loss of 15 dB and realized gain of 17 dBi is designed, simulated and fabricated. The simulation and measurement results of the compact low-cost 3D-printed dielectric lens Filtenna are in good agreement which verify the validity and uniqueness of the proposed solution for 5G and mm-wave applications.

14:10 ***Ray-Tracing Model for Elliptical Half-Geodesic Lens Antennas***

Sarah E Clendinning (KTH Royal Institute of Technology, Sweden); Francisco Mesa (University of Seville, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

This paper presents a ray-tracing-based approach to determine the radiation pattern of geodesic lens antennas with a central mirror plane. The addition of the mirror plane effectively reduces the xy-plane of the lens by 50% from the original rotationally symmetric case. The example considered in this paper has also been compressed along the y-axis by a factor of 0.7, offering a further reduction in lens size. The performance of the ray-tracing approach has been verified with full-wave simulation, with excellent agreement between the two. Our ray-tracing approach runs significantly faster than commercial software.

14:30 ***Closed-Path Toroidal-Waveguide Leaky-Wave Antenna With Directive Beam***

Shu-Lin Chen (University of Technology, Sydney, Australia); Richard W Ziolkowski (University of Arizona, USA & University of Technology Sydney, USA); Bevan Jones (Level 6, Building 11, UTS, 81 Broadway, Australia); Y. Jay Guo (University of Technology Sydney, Australia)

Leaky-wave antennas (LWAs) are promising for future wireless systems that demand compactness and seamless integration. Generally, LWAs require a termination load to absorb the power remaining in their waveguide after the excitation wave has propagated beyond their radiating elements. This feature decreases the gain and efficiency of the antenna. To avoid this issue, power recycling is achieved with the innovative closed-path toroidal-waveguide based leaky-wave antenna developed in this work. Two simple coaxial feeds are employed to generate a closed-path traveling wave in the toroidal waveguide. By utilizing a circular array of L-shaped linearly polarized (LP) radiators integrated into this waveguide, the developed LWA realizes a directive beam with a realized gain of 13.2 dBi at 9.75 GHz. A measured prototype confirmed these performance characteristics.

14:50 ***Clutter Removal in Ground-Penetrating Radar Images Using Deep Neural Networks***

Hai-Han Sun, Weixia Cheng and Zheng Fan (Nanyang Technological University, Singapore)

The clutter in ground-penetrating radar (GPR) images obscures and disguises subsurface target reflections, which greatly challenges the accurate target identification. Conventional clutter removal methods suffer from limited clutter removal capability. They either leave residual clutter or deteriorate target reflections. To address the challenges in suppressing clutter in GPR radargrams, we present a deep learning-based method that leverages

the powerful learning capability of the deep neural network to remove clutter in diverse real-world scenarios. The network takes the raw GPR radargram as the input, preserves the information related to target reflections and eliminates unwanted clutter features in an encoder-decoder manner, and finally reconstructs the clutter-free radargram. Experimental results demonstrate that the well-trained network successfully removes clutter and restores target reflections with consistent high performance in various real-world scenarios.

15:10 ***Electronically-Controlled Leaky-Wave Antenna With Dual-Band Fixed-Frequency Beam-Steering Performance***

Shanzhe Wang, Zheng Li and Jun Hong Wang (Beijing Jiaotong University, China)

In this article, an leaky-wave antenna (LWA) is proposed with dual-band fixed-frequency beam-steering performance. Based on a microstrip line (MSL) feeding and a gap waveguide (GW) excitation, the LWA can operate at 4.85 and 27 GHz respectively, and totally 100° steering range have been realized at both of the two frequencies. In addition, the experimental results for validation show desirable performance.

OCS1: Antennas and Circuits/Systems for Millimeter-Wave/Terahertz Applications

Online Room A

Chairs: Zheng Li (Beijing Jiaotong University, China), Xiang Gao (Beijing Institute of Technology, China)

13:50 ***340-GHz Antenna-Coupled High-Tc Superconducting Balanced Downconverter: Device Design and Performance Prediction***

Xiang Gao, Huanxin Li, Chuanfei Ding, Heng Liu, Xiangyuan Bu and Jianping An (Beijing Institute of Technology, China)

This work presents systematic device design and performance prediction of a 340-GHz antenna-coupled high-Tc superconducting (HTS) balanced downconverter. The downconverter integrates the lens antenna fed by two independent ports, which generates two directional beams for radio-frequency (RF) and local-oscillator (LO) coupling. Its balanced design features the coplanar waveguide (CPW) structured quadrature hybrid, matching and isolation circuits. Detailed mixing performance simulation is conducted, and the results have validated the device designs.

14:10 ***An SIW Leaky-Wave Antenna With Electronically Controlled Beam Scanning Performance***

Bang Wei, Zheng Li and Jun Hong Wang (Beijing Jiaotong University, China)

14:30 ***A Fixed-Frequency Beam-Scanning Leaky-Wave Antenna Base on Phase and Amplitude Control***

Shan Liu, Zheng Li and Jun Hong Wang (Beijing Jiaotong University, China)

14:50 ***A High-Efficiency Quasi-Optical Coupling Design for Terahertz Heterodyne Receivers***

Hanqi Zhou, Xiang Gao, Huanxin Li, Chuanfei Ding, Xiangyuan Bu and Jianping An (Beijing Institute of Technology, China)

This work presents the design and analysis of a quasi-optical coupling system of high efficiency for terahertz heterodyne receivers. The 110-GHz local-oscillator signal and the 220-GHz radio-frequency signal, are combined via a frequency selective surface (FSS) and effectively coupled into the receiver antenna module with the help of an ellipsoidal reflector. The full-wave electromagnetic analyses are carried out and the simulation results have validated the effectiveness of the quasi-optical design. Such design can be applied to cryogenic receiver systems.

15:10 ***Metasurface-Based Target Imaging and Range Detection***

Ziai Huang (Southeast University, China)

In this paper, we propose a mechanism to realize target imaging and range detection based on a single digital programmable metasurface (DPM). The DPM is used to generate biphase coded signals for range detection, and random radiation patterns for target imaging. Simulations show well performances of DPM-based target imaging and range detection. This work shows great potentials of DPMs in intelligent electromagnetic sensing.

RS1: Electromagnetic-Wave Theory and Optimization Problems

Room: C3.4

Chair: Khushboo Singh (University of Technology Sydney, Australia & Macquarie University, Australia)

13:50 ***A Modified Approach to Optimize Phase-Gradient Metasurface-Based Beam-Steering System***

Khushboo Singh (University of Technology Sydney, Australia & Macquarie University, Australia); Foez Ahmed (University of Technology Sydney, Australia); Dushmantha Thalakotuna (Macquarie University, Australia); Karu Esselle (University of Technology Sydney, Australia)

In this work, we compare two different simulation environments to aid in optimizing Phase-Gradient Metasurfaces for applications in beam-steering antenna systems. Such a strategical arrangement of supercell for optimization reduces the simulation cost and time and enhances the design efficiency. A Floquet-analysis-based optimization approach is followed to reduce the grating lobes in a Near-Field Meta-Steering system.

14:10 ***Co-Simulation Method Using Active Device Models in Microwave Simulators***

Sanghyun Kim, Jongsik Lim and Sang Min Han (Soonchunhyang University, Korea (South))

A new co-simulation method is proposed for active devices and electromagnetic resonant circuits at a microwave frequency range. From extracted/measured device parameters, the simplified equivalent model is established for each operating condition. The co-simulation procedures have been described and verified for a varactor diode model. From the experimental results, the proposed co-simulated method has shown to be well matched to the original extracted parameters.

14:30 ***Triangular Intertwined Frequency Selective Surface***

Juan A. Vásquez Peralvo (University of Luxembourg, Luxembourg); José Manuel Fernández González (Universidad Politécnica de Madrid, Spain); Juan Duncan and Symeon Chatzinotas (University of Luxembourg, Luxembourg)

This paper presents a frequency selective surface design and simulation using intertwined triangular structures. It has been discovered that by using the proposed tessellated intertwined lattice, the resonance frequency of a frequency selective surface can be improved by 22.58 % compared with other triangular structures. Additionally, this structure is used as a MEFSS to improve the miniaturization of the structure and obtain a compact, angularly stable band-pass filter. The simulations presented in this paper have been obtained using CST Microwave Studio.

14:50 ***Transient Radiation and Scattering From Wire Antennas Using a Product Nystrom Method***

John Kot (Young & Kot Engineering Research, Australia); Jeanne Young (YK Engineering Research, Australia)

The problem of radiation and scattering from a wire antenna is formulated as an integro-differential equation in space and time. The equation is solved numerically using a Product Nystrom method and an ODE solver.

15:10 ***Forward Scatter Shadow Ratio for Passive Forward Scatter Radar***

Xi Shen (The University of Western Australia, Australia); Defeng Huang (University of Western Australia, Australia)

In a forward scatter radar system, the forward scatter shadow ratio to characterize a target is introduced as the ratio of the total received power density to the incident power density for a receiver at a certain location. Numerical simulations show that the forward scatter shadow ratio is related to the size of the target as well as the position of the receiver relative to the target. It is a more suitable parameter for studying target detectability than the radar cross-section.

RS2: Reconfigurable Antennas

Room: C3.5

Chair: Yang Yang (University of Technology Sydney, Australia)

13:50 ***High-Efficiency Reconfigurable Reflectarray Based on Small Unit Cell of Ring Patch***

Sun-Gyu Lee and Yong-Hyun Nam (Hongik University, Korea (South)); Yongjune Kim (The University of Suwon, Korea (South)); Jongyeong Kim (Hanwha Systems, Korea (South)); Jeong-Hae Lee (Hongik University, Korea (South))

This paper presents a high-efficiency 1-bit reconfigurable reflectarray antenna (RRA) based on sub-wavelength

unit cell of ring patch in X-band for electronic beam-scanning applications. The aperture efficiency is maximized by optimizing illumination, spillover, and quantization efficiencies. By careful investigation of the feed structure, the aperture efficiency is optimized. The focal diameter ratio (F/D) of 0.36 is selected, resulting in a low profile RRA. In addition, the quantization efficiency is optimized by applying the reference phase shift. The aperture efficiency was measured to be 28% at 9.85 GHz (in X-band). A wide beam scanning angle of ±60˚ was also measured in both xoz and yoz planes.

14:10 ***Improvement of Aperture Efficiency of Reflectarray Antenna Using Passive and Active Unit Cell***

Yong-Hyun Nam (Hongik University, Korea (South)); Yongjune Kim (The University of Suwon, Korea (South)); Sun-Gyu Lee and Jeong-Hae Lee (Hongik University, Korea (South))

Combination of passive and active unit cell are used to improve aperture efficiency of reconfigurable reflectarray antenna (RRA). It is known that the aperture efficiency is correlated with the phase efficiency. By employing a passive unit cell, the three-state is realized to increase the phase efficiency for phase difference of 120°. The passive unit cell is designed using a rectangular patch connected to the ground plane through via holes to achieve the phase of the reflection coefficient of 180°. The one-bit active unit cell is optimally designed by the genetic algorithm (GA) to satisfy the phases of 60° and 300° for on and off states of the PIN diode, respectively. It is confirmed that the aperture efficiency of the three-states RRA is ~56% higher than that of the one-bit RRA for (θ, φ) = (0°, 0°) at 10.1 GHz.

14:30 ***Reconfigurable Phased Array Antenna Based on Liquid Crystal With Miniaturized Bandpass Filter***

Jin-Young Choi, Jun-Seok Ma, Hyun-Ji Shin and Wooksung Kim (POSTECH, Korea (South))

In this paper, a single side patterned miniaturized bandpass filter (0.02 λ0 x 0.23 λ0) is applied with 1 x 4 reconfigurable phased array antenna systems using liquid crystal (LC). The simulations show that the bandwidth meets 11.30 GHz under S11 < -10 dB, beam steering angle achieved 36°, and realized gain of main lobe > 3.20 dBi. Also, the transmission loss from biasing port to RF port satisfied < -70 dB from 1 kHz to-10 kHz, therefore, it operates bias blocking well.

14:50 ***A Reconfigurable Circularly-Polarized Ring-Slot Antenna Employing Microstrip-Line Switchable Feed Network***

Htet Wai Htun, Maodudul Hasan, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

This paper proposes a new ring-slot antenna employing a microstrip-line switchable feed network for circular polarization (CP) reconfigurable capability. For switchable functionality, diodes are incorporated between the center patch element and microstrip lines. Since the microstrip lines are used as a switchable feed structure to couple the ring-slot antenna on the ground plane, a simple configuration with no additional bias networks is realized. The CP reconfigurable property can be enabled by applying the switching voltage to the diodes. The measured results show that 10-dB impedance bandwidth of 15.8% and 17.5%, the axial ratio of lower than 3 dB, and the cross-polarization level of better than 20 dB for LHCP and RHCP are respectively acquired.

15:10 ***Dual Band Independent Phase Shift Electronically Reconfigurable Transmitarray for Ku Band***

Shozab Shafiq (Beijing Institute of Technology, China)

In this paper a high gain, low profile and compact unit cell having dual band independent phase control characteristics for transmitarray applications in Ku-band is presented. Independent phase shift and polarization control antenna array are vital for many communication applications like satellite communication, mobile communication, and SATCOM on the move etc. A dual band independent phase control transmitarray (DIPCTA) has been developed at 12.5/16.5 GHz with dual linear polarization. The proposed design utilizes two pin diode (active) loaded patches to control the uplink and down link frequency bands. Moreover, two parasitic off set feed patches are placed over the receiver layer to transmit energy through vias to the transmitter layer. There are four states available for insertion losses and phase distribution control for each upper band and lower band frequency. The upper band achieved minimum theoretical insertion losses up to 0.74 dB, whereas the lower band theoretical minimum insertion losses obtained is up to 1.34 approximately due to four-pin diode at same side. It is also noted that 180 degree phase shift achieved for upper and lower band control states is independent of each band.

Monday, October 31 15:30 - 16:00 (Australia/Sydney)

Afternoon Tea

Monday, October 31 16:00 - 17:40 (Australia/Sydney)

AS3: Student Award Competition Session 2

Room: C3.3

Chair: Stephanie Smith (CSIRO & Astronomy and Space Science, Australia)

16:00 ***Single Substrate Electrically Small Huygens Dipole Antenna Design With Reactive Loading***

Marwan Jadid (CEA & Grenoble Alps University, France); Christophe Delaveaud (CEA-LETI, France); Serge Bories (CEA, France); Anthony Bellion (CNES, France)

A single substrate electrically small Huygens dipole antenna is presented. The antenna is designed to operate at 868 MHz with an input impedance matched to 100 Ω reference impedance, having an electrical size ka of 0.61. The short-circuit excitation technique is used to excite the antenna with lumped capacitors loading on the electric dipole and the magnetic dipole. The simulated performance shows perfect matching to the reference impedance, 79% radiation efficiency, and 3.5 dBi realized gain including capacitors resistive losses.

16:20 ***A Wideband Circularly Polarized Magneto-Electric Dipole Transmitarray Antenna***

Lei Xiang, Fan Wu, Zhi Hao Jiang and Wei Hong (Southeast University, China)

16:40 ***Dual-Wideband Dual-Polarized Gridded Patch Antenna Array for 5G Millimeter-Wave Systems***

Xu Qin and Yue Li (Tsinghua University, China)

A dual-wideband dual-polarized antenna array is proposed for millimeter-wave systems. Dual bands and dual polarizations are supported by two layers of gridded patches and wideband feeding structures. A 2×2 array is composed for beam scanning. High isolations and stable radiations are achieved by several groups of fences in the array. A prototype is fabricated and measured to validate the design. The bandwidth is 23.65-31.05 GHz and 41.85-46.00 GHz for both polarizations with isolations better than 19.8 dB. Meanwhile, the average gains achieve 12.1 dBi for the lower band and 11.2 dBi for the higher band, providing a scanning range from -33° to 31° and -22° to 21°.

17:00 ***Ultra-Wideband, Wide Scanning Phased Array for SATCOM Ground Station***

Wen Dang and Wai Yan Yong (University of Twente, The Netherlands); Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden)

We present the unit cell of a linearly polarised, ultrawideband (UWB), wide scanning array antenna based on the tightly-coupled dipole antenna (TCDA) concept for cost-effective Ku/Ka-band SATCOM ground station applications. The TCDA unit cell is fed by a coaxial structure and several vias are used to broaden the bandwidth. In addition, a superstrate, functioning as a wide angle impedance matching (WAIM) layer, is employed to achieve together with an E-wall to reduce surface-waves. The simulated results show that the proposed TCDA provide a large bandwidth from 10.6 − 27.8 GHz at VSWR ≤ 2.0 at broadside radiation. Scanning angles up to 65° and 75° at the E- and H-plane, respectively, are maintained over the desired frequency of 12 − 18 GHz at VSWR ≤ 2.5.

17:20 ***Wideband Shielding Diaphragm Based on Electrically Small Single-Negative Metamaterial for Package Application***

Zhiyang Qi, Da Yi and Ming-Chun Tang (Chongqing University, China)

This paper developed a novel diaphragm, which is based on the single-negative (SNG) metamaterial for acquiring broadband compartment shielding performance in the shielding can packages of miniaturized high-speed chip components and circuits. By adopting the developed method, experimental results demonstrate it can well suppress the resonance-dominated-interference between the passive traces in single shielding can. The height and width of shielding can are 5 mm and 20 mm, respectively; the height of diaphragm is only 1.5 mm with an electrically size of 0.1λ0 at 10 GHz; and the measured (simulated) diaphragm can suppress radiofrequency interference (RFI) within 10.2-17 GHz (10-16.9 GHz), and achieve < -33.5 dB (< -40 dB) coupling within 100 kHz - 18 GHz (DC - 20 GHz).

OCS2: Multifunctional Antennas Inspired by Novel Materials and

Methods

Online Room A

Chairs: Bian Wu (Xidian University, China), Feng Wei (Xidian University & National Laboratory of Science and Technology on Antennas and Microwaves, China)

16:00 ***A Differential Low-Profile Metasurface Filtering Antenna***

Feng Wei (Xidian University & National Laboratory of Science and Technology on Antennas and Microwaves, China); Xinxin Liu and Xibei Zhao (Xidian University, China); Pengfei Zhang (Xidian University & University of Central Florida, USA)

In this paper, a differential metasurface antenna with filter-like frequency response is proposed. By introducing two pairs of notch units, three radiation nulls are generated to improve the selectivity of the proposed antenna. A low-profile of 0.08 λ0 (λ0 is the wavelength in free space at the center frequency of 5.7 GHz of the proposed antenna) is accomplished. Furthermore, high cross-polarization levels with -50.09 dB in both xoz and yoz plane at 5.7 GHz are achieved. An impedance bandwidth of 18.9% (|Sdd11|<-10dB) is realized.

16:20 ***Rapid Measurement and Estimation of Antenna Radiation Pattern Based on Characteristic Mode***

Pengfei Zhang (Xidian University & University of Central Florida, USA); Xin Xu (Xidian University, China); Feng Wei (Xidian University & National Laboratory of Science and Technology on Antennas and Microwaves, China)

The radiation pattern measurement of antennas working at relatively low frequencies is challenging [1]. Even if the outdoor measurement is operated using a large rail bracket with the probe, obtaining the full 3D pattern is complicated. In this paper, a 3D radiation pattern estimation method using measurement data in finite discrete directions is proposed based on the characteristic mode theory of the antenna, which reduces the test cost and improves the efficiency of the measurement.

16:40 ***A Wideband Rectangular DRA Excited by a Differential Power Divider***

Ayse Sari and Bin Li (Beijing Institute of Technology, China)

A differentially fed rectangular dielectric resonator antenna is presented. In this paper, a balanced power divider (PD) is used to feed the proposed DRA. The rectangular DRA can be excited by a wide bandwidth with two modes which are TE11δ and TE11(δ+1), using the differential feed. The differential impedance bandwidth is successfully simulated as about 43.3% (2.48 - 3.8 GHz). The designed differential DRA has a broadside radiation pattern with a max gain of 5.8 dB.

17:00 ***Design of Vivaldi Antenna With Ultra-Wide Passband and A Band Notch***

Xiao-Yuan Sun, Ke-Xin Guo and Bian Wu (Xidian University, China)

In this paper, a novel Vivaldi antenna with ultra-wide passband and a band notch without extra loading is proposed. The Vivaldi antenna is fed by a gradient microstrip line for the wideband match and has a rectangular groove at one side of the slot-line. The phase difference of the current between the two sides of the slot-line is disturbed seriously as the length of the rectangular groove is close to a quarter wavelength at the suppressed frequency. Therefore, the antenna obtains adjustable band notch characteristic by simply changing the length of the rectangular groove. Simulation results show that the proposed antenna provides ultra-wide bandwidth as well as a notch inside the passband with good narrow band suppression.

17:20 ***Research Advance on Multistate Spoof Surface Plasmon Polaritons Antennas***

Hao-Ran Zu, Bian Wu and Wenhua Li (Xidian University, China)

In this paper, two kinds of spoof surface plasmon polaritons (SSPPs) antennas proposed by our group are summarized. Firstly, a dual-mode SSPPs antenna is introduced, providing endfire radiation and beam-scanning radiation simultaneously. Benefiting from the double-layer SSPPs structure and high dispersion sensitivity, the large beam scanning angle and wideband endfire are achieved, and the total beam steering angle is 180°. Secondly, the beam manipulation of SSPPs antenna based on field confinement is demonstrated. By controlling the field confinement of SSPPs, different field distributions of SSPPs are realized, and then accomplish the leakage of electromagnetic energy in different directions.

RS3: 3D printing

Room: C3.4

Chair: Konstanty S Bialkowski (The University of Queensland, Australia)

16:00 ***3D Printed Anisotropic Dielectric Polarizer for 38 GHz Low Profile Horn Antenna Array***

Nelson Castro (University Carlos III of Madrid, Spain); Francisco Pizarro (Pontificia Universidad Catolica de Valparaiso, Chile); Eva Rajo-Iglesias (University Carlos III of Madrid, Spain)

The following article presents the design of a 3D-printed anisotropic material used as a circular polarizer for a low- profile horn antenna array at 38 GHz. The proposed design is manufactured and measured. Measurement results show that the use of low-loss filaments is suitable for this type of designs at mm-wave frequencies, being a cost-effective solution.

16:20 ***Radiation Characteristics of Three Dimensional Printed Meta-Surface in Broadside Condition***

Sujan Shrestha (School of Engineering, Macquarie University & Macquarie University, Australia); Syed Muzahir Abbas and Mohsen Asadnia (Macquarie University, Australia); Karu Esselle (University of Technology Sydney, Australia)

Broadside condition of Three dimensional printed Meta-surface is presented in this paper. Cubes arranged in specific patterns are considered to design the Beam Deviating Surface (BDS) and Conical Rotating Surface (CRS) where both the surfaces are arranged opposite to each other as per the increasing phase gradient. Two surfaces are 120 mm × 120 mm × 30 mm (4.8λ × 4.8λ × 1.2λ) in dimensions. The measured broadside radiation patterns in 180 degree case of orientation for CRS prototype matches well with simulated results and are wide band in operation. The measured directivity and gain values were maintained from 17 to 23 dBi throughout the operating Ku band frequency range.

16:40 ***A 3D Printing 120 GHz Lens Antenna for Terahertz 1D Beam-Scanning Applications***

Jiexin Lai and Yang Yang (University of Technology Sydney, Australia)

This paper proposes a 3D lens antenna for terahertz (THz) one-dimensional beam-scanning applications. The proposed lens antenna consists of a WR-06 waveguide and a 3D printed lens. The proposed lens can narrow the beamwidth in E-plane and has little effect on the beamwidth in H-plane. In this way, the proposed lens can be applied to a 1D linear antenna array and realize gain enhancement and beam-scanning performance. In the simulation process, the proposed lens can improve the gain of the waveguide from 6.2 dBi to 14.55 dBi. The results prove the feasibility of the proposed lens in enhancing the gain of the feed source.

17:00 ***All-Dielectric Phase Correcting Surface Using Fused Deposition Modeling Technique***

Foez Ahmed (University of Technology Sydney, Australia); Touseef Hayat (Macquarie University, Australia); Muhammad Usman Afzal (School of Electrical and Data Engineering University of Technology Sydney, Australia); Karu Esselle (University of Technology Sydney, Australia)

This paper presents a planar all-dielectric phase-correcting surface (PCS) that can be prototyped using the low-cost fused deposition modeling (FDM) technique. The non-linear phase delay via PCS is attained by its permittivity gradient profile, which is achieved by infill variation of PREPERM ABS®450 filament in different sections. As proof of concept, such PCS is employed to improve the phase uniformity of a resonant cavity antenna. Predicted results show excellent directivity improvement of 8.5 dB equivalent to its counterpart non-planar and complex composite PCS design, but PCS height is only 1.86λ.

17:20 ***A 3D-Printed Hybrid Dielectric Resonator Antenna With Low Cross-Polarization***

Yuan Yuan (The University of Adelaide, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

RS4: Energy Harvesting and Wireless Power Transfer

Room: C3.5

Chairs: Keisuke Noguchi (Kanazawa Institute of Technology, Japan), Dush Thalakotuna (University of Technology Sydney, Australia)

16:00 ***A Development of WPT Devices for Wireless-Powered Small Sensors for Home Health Care***

Konosuke Shiba and Masaharu Takahashi (Chiba University, Japan)

Recently, with the aging population and the shift from hospital-based medicine to home healthcare, Internet of Things (IoT) devices have become one of the technologies that will play an important role. It is expected that IoT devices will be used in remote medicine and the utilization of medical data. However, there are various restrictions on device operation, which can be improved by wireless power transfer. In this research, we develop a transmission/reception antenna and a rectifier circuit for a wireless power transfer system to secure power for multiple small IoT devices. In this paper, we report on the design and fabrication of the transmission/reception antenna and rectifier circuit, and power transmission experiments.

16:20 ***A 2.45 GHz Rectenna System for Far-Field Wireless Power Transfer / Energy Harvesting***

Udayabhaskar Pattapu (Santhiram Engineering College,, Nandyal & Santhiram Engineering College, India); Sushrut Das (IIT(ISM) Dhanbad, India)

In this paper, a rectenna circuit has been proposed for wireless power transfer / energy harvesting at 2.45 GHz using a four element microstrip antenna array. A filter has been used at the antenna feed to suppress the spurious responses of the array. The antenna has been connected with a matched rectifier to convert the received RF power to DC voltage. The measured maximum output voltage of the rectenna is 1.24 V for 6 dBm source power.

16:40 ***High Impedance Wire-Loop Antennas for Wireless Power Transfer Systems***

Hiroto Sakaguchi and Keisuke Noguchi (Kanazawa Institute of Technology, Japan)

Highly efficient rectenna is demanded for wireless power transfer systems. We develop high-impedance wire-loop antennas in order to obtain high rectification efficiency in mm band. We propose magnetic coupling with excited loop and wire so that the wire has role of efficient radiator. In the paper, simulations of a wire-loop antenna on an Alumina substrate are conducted. To get higher impedance and efficiency, we analyze the effects of antenna parameters on the antenna characteristics. Consequently, we designed the antenna with high resistance of 1280.6Ω and radiation efficiency of 95.1%.

17:00 ***A Study of Misalignment Effects for High- Frequency Wireless Power Transfer Systems Using a Novel Equivalent Transmission Line Model***

Kittima Lertsakwimarn (King Mongkut's University of Technology North Bangkok, Thailand); Kittisak Phaebua (King Mongkut's University of Technology North Bangkok & Faculty of Technical Education, Thailand); Danai Torrungrueng (King Mongkut's University of Technology North Bangkok, Thailand)

This paper proposes a misalignment study between transmitting (TX) and receiving (RX) antennas based on a bi-characteristic-impedance transmission line (BCITL) in wireless power transfer (WPT) systems. A pair of rectangular loop coils is designed to operate at 6.78 MHz, where it is placed side by side in a horizontal direction. In addition, the antenna characteristics at each misalignment position are computed, including the power transfer efficiency (PTE). It is shown that the PTE calculation of the WPT system based on scattering and BCITL parameters are in excellent agreement.

17:20 ***Voltage Between Two Electrodes of Resonating Capacitive Couplers for Wireless Power Transfer***

Takanori Washiro (Nippon Telegraph and Telephone Corporation, Japan); Aoi Oyane (Nagoya University, Japan)

In CWPT (Capacitive Wireless Power Transfer), it is important to measure the voltage between the electrodes of resonating couplers in order to understand the operational state and to design a safe system. However, when a probe is connected to electrodes for measurement, the electrode and the probe are capacitively coupled, causing the measured voltage to drop, making it difficult to accurately measure the voltage of couplers. Therefore, we developed a probe to accurately measure the voltage between the electrodes of a coupler for CWPT by taking parasitic capacitance into account. This paper presents the measurement results of the voltage between the electrodes of a transmitting and a receiving coupler respectively at different distance between transmitter and receiver.

WS: Workshop: Stand on the IEEE Antennas and Propagation Standards

Dr. Vikass Monebhurrun and Mr. Lars Foged

Room: C3.6

Workshops

Title: Stand on the IEEE Antennas and Propagation Standards

Speaker: Dr. Vikass Monebhurrun, CentraleSupélec, France; Mr. Lars Jacob Foged, MVG-World

Abstract: There is no additional fee to attend this workshop. Participants of the workshop will be enrolled in a drawing, and 3 lucky winners will receive a copy of the recently published IEEE Std 149-2021: IEEE Recommended Practice on Antenna Measurements (US $164 Value). The terminology standards on antennas (IEEE Std 145-2013) and radio wave propagation (IEEE Std 211-2018) are important documents that guarantee the right use of accepted terms in technical papers and reports. IEEE Std 149-2021 (antenna measurement), IEEE Std 1720-2012 (near field antenna measurement) & IEEE Std. 1502-2020 (radar cross-section measurement) prove useful when performing antenna measurements. The workshop will provide an overview of these standards that have been developed by the IEEE Antennas & Propagation Standards Committee.

Monday, October 31 18:00 - 20:00 (Australia/Sydney)

Welcome Reception (C3 foyer)

Tuesday, November 1

Tuesday, November 1 8:30 - 10:10 (Australia/Sydney)

CS1: Technological advancement in antennas and measurement: Present and future in South Korea

Room: C3.3

Chairs: Wonbin Hong (Pohang University of Science and Technology (POSTECH), Korea (South)), Dongho Kim (Sejong University, Korea (South))

8:30 *Precise Modeling of Active Component in Ka-Band Using Deep Neural Network Trained With S21 Data*

Lihour Nov, Thorn Chrek and Jae-Young Chung (Seoul National University of Science and Technology, Korea (South))

This paper proposes a method to precisely determine the R-L-C characteristics of active components, namely PIN diode and varactor diode, with an in-house developed deep neural network (DNN) approach. We use a microstrip transmission line as the measurement fixture, which also contains a DC biasing circuit to activate the component under measurement. The above structures are modeled and simulated in a full-wave electromagnetic simulator (HFSS). A through-reflect-line (TRL) calibration is applied to obtain accurate responses of the device under test (DUT), e.g., PIN diode. A vast amount of simulated transmission coefficient (S 21) data of the DUT is generated to train the DNN model, and an optimal model is considered to have a 95% testing accuracy. From this optimal model, we proceed with the testing data from simulation and obtain its R-L-C characteristics. A good agreement was obtained between the properties of the configured DUT, in the simulation, and predicted results, by the DNN model, in a broad frequency range from 24 to 40 GHz (Ka-Band).

8:50 *Overview of a Miniaturized High-Gain Reflectarray Antenna*

Dongho Kim (Sejong University, Korea (South))

This paper briefly overviews a new technique to miniaturize a reflectarray antenna (RA). Conventional RAs use a directional feeder distant from a reflectarray, which is generally in a far-field region, to clearly determine the incident phase on the reflectarray. However, we have successfully proven that the feeder can also be in a near-

field region to provide relatively high antenna gain by adding a new design constraint; enforcement of constructive interference between a direct wave from the feeder and reflected waves from the reflectarray. Accordingly, we can reduce the overall size of RAs more than 500 times compared to conventional ones in terms of electrical volume. In addition, we also verify that the miniaturized RA with one source feeder can steer its main beam electrical by way of external DC biasing.

9:10 ***Water-Loaded, Compact Ultrawideband Antenna With a Broadside Radiation Characteristic for Brain Signal Monitoring Applications***

Syed Imran Shah (Chung-Ang University, Korea (South)); Wonkyo Kim and Ick-Jae Yoon (Chungnam National University, Korea (South))

In this study, a compact, miniaturized, ultra-wideband (UWB) implantable antenna system with a broadside radiation characteristic is proposed for brain signal monitoring applications. This antenna is insulated with a de-ionized (DI) water-based insulator. The proposed antenna is designed on a 0.2 mm thick Taconic TRF-43 substrate with a relative permittivity (εr) of 4.3 and a loss tangent (tan δ) of 0.0035. It consists of a modified rectangular slot etched on the ground plane and a tapered stepped microstrip feed line to achieve a wideband frequency response. To reduce the size of the antenna significantly and to further improve impedance matching and the broadside radiation characteristics, high permittivity DI water is used as an insulator. The entire system is composed of 10 × 9 × 0.7 mm 3 size antenna, batteries, sensors, and electronic components: they are enclosed in a 3D printed biocompatible casing. The system is designed and analyzed using CST and Sim4Life. It is found that the antenna exhibits -10 dB impedance bandwidth of 129% ranging from 3 GHz to 14 GHz with a broadside radiation characteristic. The peak gain is -19 dBi at 3 GHz. Based on the performance attributes, simplicity, compactness, and wideband impedance bandwidth, it is believed that this could be a potential implantable system for modern health and brain monitoring devices.

9:30 ***28 GHz 5G OTA Test Using Optically-Transparent Reflective Surface Fabricated by Electroforming***

Cheonga Lee (Pohang University of Science and Technology, Korea (South)); Dongsoo Jun (Yonsei University, Korea (South)); Myeonggin Hwang, Daehyeon Kim, Youngno Youn, Suho Chang and Donggeun An (Pohang University of Science and Technology, Korea (South)); Sang-Hyun Park and Chan-Byoung Chae (Yonsei University, Korea (South)); Wonbin Hong (Pohang University of Science and Technology (POSTECH), Korea (South))

This paper validates the feasibility of deploying passive reflective surfaces to eliminate the radio shadowing regions in mmWave (28 GHz) fifth-generation (5G) wireless communications. The proposed optically-transparent reflective surface is fabricated by an electroforming process. To confirm the performance of the proposed reflective surface, the radiation pattern is measured in a far-field chamber. In addition, 5G real-time over-the-air (OTA) tests are implemented. Through single-tone and error vector magnitude (EVM) OTA measurements, the received power, EVM, and link throughputs are measured. As a result, radio shadowing regions are diminished in a non-line-of-sight (NLOS) path by approximately 15 dB through the deployment of the proposed optically transparent reflective surface.

9:50 ***Universal Design Method for Traveling Wave Series-Fed Array Antennas***

Sangmin Lee and Sangjo Choi (Kyungpook National University, Korea (South))

Microstrip traveling-wave series-fed array antennas are popularly utilized for millimeter-wave radars and communication systems due to low loss from a feeding network. However, the design difficulty compared to parallel-fed arrays for in-phase radiation is inevitable due to the loading and mutual coupling effects between the antenna elements connected in one single feeding line. For the in-phase radiation, the distances between antenna units have been tuned, but the tuning process is cumbersome due to the interdependence between the units. This paper introduces a universal and tuning-free design method of microstrip traveling-wave series-fed arrays for in-phase radiation. We designed series-fed patch and comb-line arrays operating at 76.5 GHz based on the proposed method and proved the in-phase radiation with the main beam at the boresight and a sidelobe level near -20 dB.

CS2: EurAAP Special Session

Room: C3.6

Chairs: Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden), Astrid Algaba-Brazález (Ericsson AB, Sweden)

8:30 *Monopulse Feeding Network Based on New Gap Waveguide Planar Magic-Tees*

Enlin Wang (Chalmers University of Technology, Sweden); Tianling Zhang (Xidian University, China); Ashraf Uz Zaman (Chalmers University of Technology, Sweden); Thomas Emanuelsson (Gapwaves AB, Sweden); Per-Arne Thorsen and Sam Agneessens (Ericsson AB, Sweden); Jian Yang (Chalmers University of Technology, Sweden)

A compact low-loss monopulse feeding network based on gap waveguide (GW) with two new planar GW magic-Ts is proposed. The four ports of the two planar Magic-Ts are in the same plane, which makes it possible to cascade magic-Ts to achieve a monopulse feeding network in a single plate for one polarization. The bandwidth of simulated reflection coefficient below -10 dB of this monopulse feeding network is 23.5%, covering 30-38 GHz. This network is a good candidate for planar monopulse antennas.

8:50 *Overview of Research on Metalenses and Geodesic Lenses for 5G/6G Applications in Ericsson*

Astrid Algaba-Brazález (Ericsson AB, Sweden); Lars Manholm and Martin Johansson (Ericsson Research, Sweden); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

In this contribution, we outline the challenges and opportunities of designing parallel-plate lenses implemented with metasurfaces (i.e. metalenses) or with geodesic surfaces (i.e. geodesic lenses), for next generation communication systems (5G and beyond). The requirements that we studied in our investigations are low scanning loss, high efficiency, high crossover level, polarization diversity, wide scanning range, low antenna profile, manufacturing simplicity, and cost-effectiveness. These requirements are key when designing and developing antennas for 5G and beyond.

9:10 *Wide-Band Wide-Scan High-Gain CTS Array for SatCom Applications in PCB Technology*

Adham Mahmoud (Institut d'Électronique et de Télécommunications de Rennes, France); Ronan Sauleau (University of Rennes 1, France); Mauro Ettorre (University of Rennes 1 & UMR CNRS 6164, France)

This communication presents a continuous transverse stub (CTS) array with a gain larger than 38.5 dBi at K/Ka band (17 GHz - 31 GHz) for SatCom applications. The CTS array is fabricated in printed circuit board technology (PCB) with a stack-up of 15 layers without any buried and blind vias by resorting to a novel contact-less transition among layers. A very-broadband quasi-optical beamformer made by a pillbox coupler is used as a feeder. Such a coupler is optimized to cover the K/Ka band. A ±65 ° beam steering angle in elevation is obtained. The steering is achieved through a mechanically moving horn placed in the focal planer of the pillbox coupler. The antenna's aperture is a square with 62.2λ0 side length and a thickness of approximately 6λ0, where λ0 is the free space wavelength at 31 GHz.

9:30 *A High-Efficiency 3D-Printed E-Band Dielectric Transmitarray for Integrated Space and Terrestrial Networks*

Kun Wu and Peiyuan Qin (University of Technology Sydney, Australia); Shu-Lin Chen (University of Technology, Sydney, Australia)

A highly efficient wideband transmitarray working at E band is developed in this paper. This transmitarray is composed by 1010 dielectric cells and fabricated through three-dimensional (3D) printing technology. To obtain the required phase distribution of the array, the height of dielectric cells is adjusted. To reduce the phase error under oblique incident angles, multiple-angle phase distribution is analyzed. This transmitarray can work within a wideband from 60 to 90GHz. The peak gain can reach 23.4 dBi at 74 GHz with the maximum aperture efficiency of 60.9%.

9:50 *Integrated mmWave 1x4 Half-Circle Monopole Antenna Array for Board-To-Board Communication*

Bernhard Klein and Ronny Hahnel (Technische Universität Dresden, Germany); Dirk Plettemeier (Dresden University of Technology, Germany)

An integrated 1x4 antenna array consisting of four planar half-circle monopole antennas for the frequency range from 165 GHz to 195 GHz has been designed. This antenna array is fabricated in the IHP SG13 semiconductor process. Besides the bandwidth of more than 30 GHz, a maximum realized gain of 5.2 dBi is achieved at 195 GHz. The overall chip size is 1.26 mm x 3.66 mm.

RS5: Filters and Filtering Antennas

Room: C3.4

Chair: Girdhari Chaudhary (Jeonbuk National University, Korea (South))

8:30 ***A Design of Optimum Distributed Highpass Filter Using Defected Ground Structure***

Minseong Kim (Soonchunhyang, Korea (South)); Sohui Kim (University of Soonchunhyang, Korea (South)); Juyoung Jung (Soonchunhyang University, Korea (South)); Hyeseong Cha (Soonchunhyang, Korea (South)); Yuseong Choi (University of Soonchunhyang, Korea (South)); Jaebok Lee (ERANGTEK Co., Ltd, Korea (South)); Youna Jang and Dal Ahn (Soonchunhyang University, Korea (South))

This paper proposes a third-order optimum distributed high-pass filter (HPF) using a dumbbell-shaped defected ground structure (DGS). The optimum distributed HPF with broadband bandwidth has a difficulty of fabrication due to its high impedance. The proposed circuit is to extend the line width when the cut-off frequency is 2GHz and passband is up to 8.5 GHz. The line width of the proposed circuit is increased about 3 times compared to the conventional circuit. As the measurement results of the proposed circuit, the insertion loss is -0.47dB, the reflection loss is -11.81dB. The measured results are well matched with the simulation results except the fabrication errors.

8:50 ***A Design of 3-Pole Coupled Line Bandpass Filter Using Group Delay Analysis Approach***

Jaehun Lee, Girdhari Chaudhary and Phanam Pech (Jeonbuk National University, Korea (South)); Yongchae Jeong (Chonbuk National University, Korea (South))

In this paper, we present a design of 3-pole coupled line bandpass filter using group delay (GD) analysis approach. The proposed 3-pole BPF consists of two-coupled line with short-circuited stub instead of four coupled lines conventional BPF. The design equations are derived by equating GD of the proposed and conventional 3-pole BPF. The GD value of the proposed BPF is controlled by adjusting fractional bandwidth of filter. For proof of concept, the proposed BPF was designed and fabricated at center frequency of 3.50 GHz. The measured results are well agreed with simulations and theoretically predicted results. The measurement results revealed that the proposed BPF achieved the insertion loss of 0.8 dB with fractional bandwidth of 21.71% (760 MHz) and GD of 0.92 ns.

9:10 ***Filtering Differential Phase Shifter With Arbitrary Prescribed Wideband Flat Phase Difference and Group Delay***

Girdhari Chaudhary and Samdy Saron (Jeonbuk National University, Korea (South)); Yongchae Jeong (Chonbuk National University, Korea (South))

Differential phase shifter is critical components for RF beamforming and feeding networks in phased array systems. In this paper, we present group delay (GD) analysis approach to design filtering differential phase shifter with arbitrary prescribed flat phase difference and GD. The proposed differential phase shifter consists of coupled lines with short-circuited stub in main and reference branch. The flat phase difference within passband frequency is achieved by maintaining same GD of main and reference branch. For validation, differential phase shifters with phase difference of 90o, 180o, 270o, and 360o are designed and simulated. The simulated results show that three-reflection poles and flat phase difference are achieved with passband fractional bandwidth of 20%.

9:30 ***Design of Compact Bandpass Filter With Stub-Loaded to the Closed Loop Resonator***

Taehoon Kang (University of Soonchunhyang, Korea (South)); Seo Koo (Soonchunhyang, Korea (South)); Jiwon Kim (Soonchunhyang Univ, Korea (South)); Hyunduk Kang (Electronics and Telecommunications Research Institute (ETRI), Korea (South)); Heon-Jin Hong and Young Jun Chong (ETRI, Korea (South)); Youna Jang and Dal Ahn (Soonchunhyang University, Korea (South))

In this paper, a compact 3-order Band-pass filter (BPF) is proposed using a resonator that adds stub-loaded to the closed loop resonator. In consideration of coupled with 50Ω feeding line, the first and last resonator of λ0/4 is folded type. The proposed filter is designed and fabricated with a fractional bandwidth of 8% at 1GHz center frequency. As compared to the area of the conventional interdigital BPF, a decrease of 50.04% is verified. Experimental results have shown good agreement with simulated ones.

9:50 ***Fast Optimization of Unbalanced Filtering Antenna and Phase Controlled Transmission Line With Arbitrary Reference Impedances***

Teng Chang and Hsi-Tseng Chou (National Taiwan University, Taiwan)

In this paper, an effective synthesis method is presented for fast design of filtennas. The bandpass Q-factor, bandwidth, and order are incoporated into the antenna design cascading phase controlled transmission lines to produce an unbalanced filtering feature. The presented synthesis reduces the design cycle time and also predict the filtering performance. This method is validated by designing a three-order bandpass filtenna at 2.4 GHz to

achieve a broad bandwidth. The simulated results agree very well with commercial simulation tools. The technique provide great flexibility for a filtenna design.

RS6: Lenses

Room: C3.5

Chairs: Jihoon Kim (Nagoya Institute of Technology, Japan), Withawat Withayachumnankul (The University of Adelaide, Australia)

8:30 ***Evaluation of Luneberg Lens Focusing Performance in a Finite Size Anechoic Chamber***

Toshiyuki Miyazaki (Hokkaido Reserch Organization, Japan); Takashi Kusaka (Hokkaido Research Organization, Japan); Fumihiro Takahashi (Green & Life Innovation, Inc., Japan); Takashi Hosokawa (Nitto Seimo Co., Ltd., Japan)

In the coastal fishery, it is becoming more important to measure the position of fishing gear such as set-net using SAR satellites. In this study, we studied the retroreflective structure using the Luneberg lens in order to detect the floating buoys such as fishing gear with the SAR satellite radar. We report on our research on a method for evaluating the light gathering performance of Luneberg lenses in an anechoic chamber of finite size.

8:50 ***275-GHz Planar High-Gain Resonant Cavity Antenna With Effective Medium***

Mingxiang Stephen Li (The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia); Withawat Withayachumnankul (The University of Adelaide, Australia)

In this paper, we present a planar high-gain resonant cavity antenna (RCA) with an integrated waveguide feed for the WR-3 frequency band from 220-330 GHz. The conventional extended hemispherical lens and resonant air cavity are replaced by two effective medium layers of cylindrical hole arrays, which can be fabricated by direct laser drilling on both sides of a high-resistivity float-zone (HRFZ) silicon wafer. The proposed design presents an advantage particularly in its low profile, with an overall thickness of only two wavelengths. The lens antenna is designed through full-wave simulations, and the achieved results suggest a maximum broadside gain of 20 dBi at 275 GHz, with a 3-dB bandwidth of around 18%

9:10 ***Design for Uniform Aperture Distribution of 2×2 Lens Array Using Concave-Convex Lens in THz Band***

Bazilah Baharom (Nagoya Institute of Technology & NITech, Japan); Yoshiki Sugimoto and Kunio Sakakibara (Nagoya Institute of Technology, Japan); Rohani Bakar (Nagoya Institute of Technology (Nitech), Japan); Nobuyoshi Kikuma (Nagoya Institute of Technology, Japan); Yoshihide Yamada (Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, USA)

A lens array has been developed to reduce the height of the lens and has proven to achieve the same gain as a large single lens antenna with a low antenna profile. However, the amplitude is not completely uniform in the aperture distribution. Therefore, a concave-convex lens shaping is applied to the lens element to improve the lens aperture uniformity. The proposed concave-convex shaped lens array is demonstrated by electromagnetic simulation at 300GHz achieving high gain at 35.6dBi with reliable side-lobe-level (SLL) at −11dB.

9:30 ***Design of 275 GHz Beamforming Network Using Partial Maxwell's Fisheye Lens***

Jihoon Kim, Kunio Sakakibara, Yoshiki Sugimoto and Nobuyoshi Kikuma (Nagoya Institute of Technology, Japan)

A 5×10 beamforming network is designed on a single printed circuit board at 275 GHz, using a partial Maxwell's fisheye lens (MFL). The permittivity graph of the profile is presented, and the ray path is estimated. The permittivity is controlled by arranging the non-plated via-holes regularly. A practical BFN design is verified by the simulation tool (HFSS), and beam scan angle is appeared as ±50°.

9:50 ***A Dual-Polarized High-NA Achromatic Transmission Huygens' Metalens***

Xiaoluo He (City University of Hong Kong, Hong Kong)

In this paper, we present the first dual-polarized achromatic metalens made from a Huygens' metasurface element. Employing a novel Huygens' architecture with miniaturized size and improved tuning range, we achieve wideband, linear-phased, highly transmissive elements capable of generating a large range true-time-delay. This allows us to construct a dual-polarized achromatic metalens with a large numerical aperture. As a proof of

concept, we design a dual-polarized achromatic metalens for which the focal length is maintained at 6.4 ± 0.15λ c across the operation band (K-band, 21.5-26 GHz), where λ c = 12.5 mm is the wavelength corresponding to the center frequency of 24 GHz. The simulated focusing efficiency is over 65% across the operation bandwidth. The combination of the miniaturized unit cell and increased tuning range allows this dual-polarized achromatic metasurface to have a numerical aperture of 0.64 - which is the highest known among achromatic metalenses in the microwave region. This metasurface shall find attractive applications in broadband imaging and communication at microwave and mmwave frequencies.

Tuesday, November 1 10:10 - 10:35 (Australia/Sydney)

Morning Tea

Tuesday, November 1 10:35 - 12:40 (Australia/Sydney)

IS1: Invited talk session 1：Metasurface, Beam Forming and Antenna Measurement

Room: C3.3

Chair: Chao-Fu Wang (National University of Singapore, Singapore)

1. 10:35 -Physical implementation of Huygens' Metasurface for High Refraction Efficiency

Ikmo Park (Ajou University, Korea); Gangil Byun (Ulan National Institute of Science and Technology, Korea)

2. 11:00 - Recent Advances on Waveguide-Type Beam-Switching Matrices

Jiro Hirokawa (Tokyo Institute of Technology, Japan)

3. 11:25 - Beamforming Techniques with Leaky-Wave Antennas

Jose Luis Gomez Tornero (Technical University of Cartagena, Spain)

4. 11:50 - Antenna and Receiver Development for Radio Astronomy at CSIRO

Stephanie Smith (CSIRO, Australia)

5. 12:15 - Phaseless, Single Hemispherical Plane Near Field Measurement for OTA Test.

Hiroyuki Arai (Yokohama University, Japan)

IS2: Invited talk session 2: Antennas for Medical, Mobile and Base Station Applications

Room: C3.6

Chair: Can Ding (University of Technology Sydney (UTS), Australia)

1. 10:35 -Antennas in Medicine: Miniaturization, Bandwidth Enhancement, and Multi-Polarization

Yongxin Guo (National University of Singapore, Singapore)

2. 11:00 - Wideband MIMO Array Design for 5G Smartphone Applications Operating in the NR Band n77/n78/n79 and NR-U Band n46/n96

Chow-Yen-Desmond Sim (Feng Chia University, Taiwan)

3. 11:25 - Reducing Hand Effect of Terminal Antennas Using Characteristic Mode Theory

Hui Li (Dalian University of Technology, China)

4. 11:50 - Filtering Antennas and Its Application to Aperture-Shared Multiband Base-Station Arrays

Xiuyin Zhang (South China University of Technology, China)

5. 12:15 - Mutual Coupling Reduction for Single and Dual-band Shared Aperture Base Station Arrays

Xiaoming Chen (Xi'an Jiaotong University, China)

Tuesday, November 1 12:40 - 14:00 (Australia/Sydney)

Lunch

Tuesday, November 1 14:00 - 15:40 (Australia/Sydney)

CS3-I: Recent advances in array antenna and metasurface engineering (Part I)

Room: C3.3

Chairs: Ikmo Park (Ajou University, Korea (South)), Gangil Byun (Ulsan National Institute of Science and Technology (UNIST), Korea (South))

14:00 ***A Compact Wideband Solar-Cell Integrated Antenna***

Ahmed Ali and Ikmo Park (Ajou University, Korea (South))

This paper describes a wideband and ultra-low profile solar-cell integrated antenna with a high form factor. An indium gallium selenide-based solar cell is utilized to make the built-in solar-cell antenna, which is designed to operate from the solar cell using a slot that is carved into it. The proposed design has an ultra-low profile structure of 0.0056 λo at 2.96 GHz with overall dimensions of 50 mm × 27 mm × 0.571 mm (0.49 λo × 0.26 λo × 0.0056 λo at 2.96 GHz). Moreover, the presented design has a -10 dB impedance bandwidth of 43.24%, a maximum gain of 2.45 dBi, a form factor of 99.33%, and optical transparency of 100%.

14:20 ***A Simultaneous Beam Steering and Polarization Converting S-Band Transmitarray Antenna***

Myeongha Hwang and Gyoungdeuk Kim (Pusan National University, Korea (South)); Jongyeong Kim (Hanwha Systems, Korea (South)); Sangkil Kim (Pusan National University, Korea (South))

In this paper, a multi-functional transmitarray antenna consisting of miniaturized unit cells for S-band radar applications is presented. The unit cell size is 0.4λ0 × 0.4λ0, and it is composed of a receiving (Rx) antenna, a miniaturized inductively-loaded reflection-type phase shifter, a PIN diode SPDT switch for polarization conversion, and a dual-polarization transmitting (Tx) antenna. The types of Rx and Tx antennas are coupled-fed stacked patch antennas. The designed reflection-type analog phase shifter has a 36 % smaller area than the conventional reflection-type hybrid coupler-based phase shifter. It has a 3-bit phase-shifting capability realized with a 0 ~ 330° analog phase shifter. The designed SPDT PIN diode switch can select the polarization of the transmitted wave and accept a high input RF power of 23 dBm. The proposed 8 × 8 transmitarray antenna with F/D of 0.33, made from its unit cell, has a gain of about 7.9 dBi and performs 90° beam steering for vertical-to-horizontal and vertical-to-vertical polarization conversions at the center frequency.

14:40 ***Reconfigurable Metasurface With a Novel Coupled Line Structure for Ka-Band***

Sebastian J. Verho, Van Thang Nguyen, Philip A. Dzagbletey and Jae-Young Chung (Seoul National University of Science and Technology, Korea (South))

A reconfigurable 4x4 metasurface structure for Ka-band is proposed. The reconfigurability is achieved with the control of varactors and PIN diodes which enable electrical beam steering and polarization control respectively.

Moreover, a novel coupled line structure is employed to eliminate lumped components, e.g. inductors and resistors, which are typically used to bias the above-mentioned components. The novel structure provides a ground connection while having high coupling which ensures robust performance at the operation frequency of 28 GHz. To demonstrate the operation, simulation results of the 4x4 structure are presented at 0° and ±30° steering angles with a gain of 11.2 dB and 4.5/4.4 dB respectively. The cross-polarization discrimination levels for vertical and horizontal polarization are −20.0 dB and −22.8 dB respectively.

15:00 ***Liquid Crystal Based High-Efficiency Reconfigurable Metasurface***

SoYul Han, Ashwini Kumar Arya and Sanghoek Kim (Kyung Hee University, Korea (South))

Manipulation of electromagnetic (EM) waves using metasurface is enthusiastically in research nowadays. For the last decades, beam tilting, polarization control, and various mechanisms of EM waves manipulation utilizing metasurface have been reported. However, with the fixed geometry, static metasurface can be utilized only for a certain environment. To overcome the limitation of the static metasurface, recent research on dynamic metasurface has demonstrated a new horizon. This paper presents a reconfigurable metasurface utilizing a liquid crystal substrate designed based on Huygens' principle for EM wave reflection in X-band. With a normal incident wave, different reflection angles along with high efficiency are observed. The results agree well with the numerical calculation. This paper demonstrates the rigorous design methodology of the reconfigurable metasurface reflector in detail which can be applied to radar systems and beam-forming applications.

15:20 ***A Compact Broadband Quasi-Isotropic Antenna for Wireless Energy Harvesting Applications***

Sonapreetha Mohan Radha, Mee-Su Lee and Ick-Jae Yoon (Chungnam National University, Korea (South))

A compact broadband quasi-isotropic antenna is presented in this paper. Slits are established on a tapered crossed dipole antenna to enhance the bandwidth as well as the isotropic antenna performance. The proposed antenna shows an 87 % of impedance bandwidth in the frequency range of 1.8-4.2 GHz. The quasi-isotropic radiation performance, that is, the maximum gain deviation less than 6 dB, is observed for the frequency range of 2.1-3.2 GHz, with a 41.5 % bandwidth. The simulation results are verified experimentally.

CS4: ASEAN research on Antenna and propagation for 5G Application

Room: C3.6

Chairs: Peiyuan Qin (University of Technology Sydney, Australia), Mohamad Kamal A Rahim (Universiti Teknologi Malaysia, Malaysia)

14:00 ***Metamaterial Based Beamforming Network Integrated With Wilkinson Power Divider***

Arshad Karimbu vallappil (Islamic University of Madinah, Saudi Arabia); Mohamad Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia); Bilal A. Khawaja (Islamic University Of Madinah, Saudi Arabia & National University of Sciences and Technology (NUST), Pakistan); Noor Asniza Murad (University Technology Malaysia, Malaysia)

This paper presents a switched beam-forming network (SBFN) integrated with a power divider for 5G applications. The proposed design consists of a metamaterial-based 4 × 4 butler matrix (BM) and 1×2 Wilkinson power (WPD) divider. The simulated results show that the proposed design achieved an outstanding insertion-loss of -9 ± 1dB and excellent reflection coefficient between the frequency range of 3.2GHz - 3.7GHz. The simulated phase differences achieved between the output ports are -45 o ± 8 o for the excitation of Input Port-1. The proposed design is suited for a 5G switched-beam antenna array (SAA) because of its enhanced bandwidth and compact structure of BM and WPD.

14:20 ***Broadband Metamaterial Polarizing Reflector at X-Band Frequencies for RIS Application***

Mohamad Kamal A. Rahim, Nur Syahirah Mohd Yaziz and Noor Asmawati Samsuri (Universiti Teknologi Malaysia, Malaysia)

A broadband metamaterial reflector for polarization manipulation based on square split ring resonator and cross sign structure is proposed in this paper. The ability of the metamaterial reflector to transform a linearly polarized incident wave to a cross-polarized or circularly polarized wave is shown. Simulation results shows a cross-polarization average polarization conversion ratio of greater than 80% for normal incident linearly polarized waves over a frequency range of 7.7 GHz to 10.7 GHz. The reflector is planned to be used in reconfigurable intelligence surface (RIS) applications where signal polarization control is critical.

14:40 ***Design Consideration of Dual-Polarized Angle- Selective Surfaces***

Zhenting Chen, Xu Rui and Zhongxiang Shen (Nanyang Technological University, Singapore)

Angle-selective surface (ASS) is a two-dimensional periodic structure that allows plane electromagnetic waves of certain incident angles to transmit, while blocking waves from other angles. In the literature, such ASS is also named as spatial filters that can be used to suppress the side lobes of antennas and arrays.

This paper describes the design of a dual-polarized angle-selective surface based on three layers of frequency-selective surfaces. The design concept and theoretical formulation will be presented in detail. A practical design example will also be provided to demonstrate the validity of the formulated design procedures.

15:00 ***Circularly Polarized Patch Antenna With Rotated S Shape Slot for 5 G Application***

Tamara Zuhair Fadhil AL-Baiyaa (Universiti Teknologi Malaysia (UTM), Malaysia & University of Information Technology and Communications, Iraq); Noor Asniza Murad (University Technology Malaysia, Malaysia); Mohamad Kamal A. Rahim and Mohamad Rijal Hamid (Universiti Teknologi Malaysia, Malaysia)

This paper presents a mid-band circularly polarized slot antenna for fifth-generation applications. An S-shaped slot is etched into a rectangular patch of the microstrip antenna is applied to realize circular polarization radiation. Rotating the S-shaped slot improves the antenna's axial ratio bandwidth and gain at 3.5 GHz. Probes feeding a perturbed rectangular patch could excite right-hand circular polarization and left-hand circular polarization. Moreover, the probe feed position is optimized to widen the impedance bandwidth of the proposed antenna. The multi-band can be applied in many wireless applications.

15:20 ***Tilted Directional Couplers Based Nolen Matrix Beamforming Network for Fifth Generation Multi-Beam Application***

Joseph Lim, Norhudah Seman and Nurazulfathul Rozali (Universiti Teknologi Malaysia, Malaysia)

In this paper, a switched-beamforming network with integrated linear microstrip patch antenna array is designed at 26 GHz for fifth generation (5G) application. The 4 x 4 Nolen matrix formed by the tilted directional couplers and Schiffman phase shifters is proposed as the beamforming network to provide the unique progressive phase differences to the output ports for switchable multi-beams that directed at specific directions. Its performance and capability of switchable beams are assessed, analyzed and validated at 26 GHz.

OCS3: Compact and high-performance planar antennas and their arrays

Online Room A

Chairs: Ming-Chun Tang (Chongqing University, China), Junping Geng (Shanghai Jiaotong University, China)

14:00 ***A Low Profile Magneto-Electric Dipole Antenna Based on Spoof Surface Plasmon Polaritons***

Rui Zhao (Shanghai Jiao Tong University, China); Junping Geng (Shanghai Jiaotong University, China); Jingzheng Lu, Silei Yang, Xudong Tang, Da Su, Yangzhou Zhang, Ao Zhang and Haotian Li (Shanghai Jiao Tong University, China)

A novel low profile magneto-electric (ME) dipole antenna based on spoof surface plasmon polaritons (SSPPs) is proposed. The magneto and electric dipole of the ME antenna both are composed of slow-wave SSPPs structure, which effectively decrease the size of the antenna. A coplanar waveguide (CPW) is used to transform the guided wave into slow-wave to further expand the impedance bandwidth. An antenna prototype is designed and simulated. Simulated results show that the designed antenna achieves an impedance bandwidth of 22.8% for V SW R < 2 from 2.44 to 3.07 GHz and 7.8% 1-dB gain bandwidth from 2.44 to 2.65 GHz with a low profile height (0.10λ 0, λ 0 is the wavelength of 2.55GHz) and high front-to-back ratios.

14:20 *A Low-Profile Parasitic Dipole Antenna With Improved Bandwidth and Gain*

Ruolei Chai, Shi Ting and Ming-Chun Tang (Chongqing University, China)

A low-profile dipole antenna with improved bandwidth and gain is presented in this work. The basic dipole is realized with one parasitic radiation arm, corresponding to high gain at low-profile condition. Moreover, a parasitic patch with eight slots etched on it is located above the dipole for bandwidth enhance. Finally, the developed dipole antenna is achieved with a low-profile of only 0.068 λ 0 (λ 0 is the operating wavelength in freespace). It exhibits a -10 dB impedance bandwidth of 8.5% (0.79-0.86 GHz) and a high gain of 8.1-8.9 dBi with a stable gain fluctuation of 0.8 dBi over the operating band.

14:40 *A Wide-Band and Wide-Beam 1-Bit Phase Reconfigurable Antenna*

Xin Li and Qiang Cheng (Southeast University, China)

In this paper, a 1-bit phase reconfigurable antenna is presented for wide-band and wide-beam applications. The proposed antenna is composed of a radiator and a switchable feeding structure. We choose the aperture-coupled stacked patch as the radiator to broaden the operating bandwidth. Due to the structural symmetry, a stable phase difference of 180 degrees is achieved by switching the working state of the feeding part. In addition, a wide-angle matching layer and metallic walls are introduced in the antenna to widen the beamwidth of the radiation pattern. To verify our design, the proposed antenna is designed and simulated. The -10-dB impedance bandwidth ranges from 11 to 12.8 GHz. The half-power beamwidths (HPBWs) for the proposed antenna in E-plane and H-planes are 156°and 151° respectively.

15:00 *A Parasitic Microstrip Linear Array With Customizable Tilted-Beam Radiation*

Zhengyi Sun, Mei Li and Ming-Chun Tang (Chongqing University, China)

A single-layer microstrip parasitic array with customizable tilted-beam radiation performance is presented. The antenna consists of one driven sub-wavelength patch and eight parasitic patches and the tilt angle is determined by the refractive index distribution of the patch units. The index-modulation principle is derived based on the generalized law of refraction. According to this principle, the size of the patch unit can be adjusted to control the tilt angle. This paper uses I-shaped patch unit to configure the tilted-beam antenna. Simulation results manifest that the antenna has a large tilt angle of 60° off boresight and a broad bandwidth of 19.31%.

15:20 *Series-Fed Slit Ring Resonator Antenna Array With Wide Fan-Beam and High Gain*

Hyunyoung Cho and Seong-Ju Lim (KAIST, Korea (South)); Sol Kim (Korea Advanced Institute Science and Technology, Korea (South)); Ju-Ik Oh, Chanhee Lee and Jong-Won Yu (KAIST, Korea (South))

A low-profile linear array antenna having an end-fed series-fed structure for high gain with a wide fan beam was proposed. The conventional microstrip antenna, a series-fed patch antenna, and the proposed antenna were analyzed with an omnidirectional radiating magnetic current, and a wide fan beam was created using a coupled slit-ring resonator. The antenna array consists of 72ohm microstrip lines and four slit-ring resonators acting as radiating elements. The proposed antenna was fabricated and measured. The proposed antenna has measured results, the peak gain is 10.3 dB, and the half-power beam-width(HPBW) of E-plane is 129-degree. The proposed antenna has linear polarization, a wide fan-beam, and high gain.

OCS4: Advanced Research and Development of Dielectric Components

Online Room B

Chairs: Yongmei Pan (South China University of Technology, China), Shaoyong Zheng (Sun Yat-sen University, China)

14:00 *Wideband Circularly Polarized Antenna on Glass Substrate With High Optical Transparency*

Wen Zhong and Yu-Xiang Sun (Shenzhen University, China)

14:20 *Dual-Band Dielectric Resonator Antenna With Self-Decoupling Characteristics*

Qixuan Lai and Yongmei Pan (South China University of Technology, China)

In this paper, a self-decoupled dual-band multiple-input multiple-output (MIMO) dielectric resonator antenna (DRA) array is implemented using the higher-order modes. Specifically, the TE113(y) and TE115(y) modes are simultaneously excited in the active DRA to generate two operating frequency bands, and they further excite the TE112(y) and TE114(y) modes in the adjacent coupled DRA through the near-field coupling. Since both the TE112(y) and TE114(y) modes have a rather weak field intensity at the feeding slot, little energy can be coupled

to the feed line of the coupled antenna through the slot. As a result, a dual-band DRA with self-decoupling characteristics is achieved without requiring any extra decoupling structure. The simulated results show that the DRA obtains usable bandwidths (with |S11| < −10 dB and |S21| < −20 dB) of 3.5% and 4.6% at two operating bands, and the maximum isolation levels in the passbands are over 30 dB.

14:40 ***A Filtering Power Divider With Wide Bandwidth Using a Single Dielectric-Loaded Cavity Resonator***

Weisheng Tang (Sun Yat-sen University, China); Yong Xuan Zheng (Sun Yat-Sen University, China); Shaoyong Zheng (Sun Yat-sen University, China)

This paper presents a novel wideband filtering power divider based on a multi-mode dielectric-loaded cylindrical cavity resonator. The resonator is constructed by a metal-embedded cylindrical dielectric disk loaded at the center of a cylindrical cavity, and fed by three probes with 120-degrees displacement with each other. Three resonant modes (TM010, TE111 e, TE111 o) can be gathered for operation by properly tuning the lengths of feeding probes and the radius of the dielectric disk. Two transmission zeros can be respectively generated at the upper and lower stopband. For demonstration, a prototype operating at 3.5 GHz was designed, fabricated, and measured. A good agreement between the simulation and measurement can be observed. The measured results suggest a wide fractional bandwidth of 33.3%.

15:00 ***Design of a Wideband Millimeter-Wave Circularly Polarized Lens Antenna***

Wenyi Teng (China); Kaixu Wang (Harbin Institution of Technology, China)

In this paper, a wideband and circularly polarized lens antenna with high gain has been designed for millimeter-wave applications. The antenna is mainly composed of several dielectric slabs with different lengths. The slabs can not only act as a polarizer for circularly polarization (CP), but also as a lens, which results in size reduction and loss reduction. The antenna can be manufactured with 3D printing technology with a low cost. The proposed antenna can operate from 21.8 GHz to 75 GHz with the reflection coefficient<-10dB and the axial ratio bandwidth (AR<3dB) is from 20.8 GHz to 64 GHz. Besides, the peak gain of the antenna is 19.6dBic. The height of the antenna is around 3.2λ0

RS7: Conformal and Flexible Antennas

Room: C3.4

Chairs: Lizhao Song (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia), Jeong-Su Park (University of Engineering, Korea (South))

14:00 ***E-Band Multibeam Conformal Transmitarrays for Beyond 5G Wireless Networks***

Lizhao Song (CSIRO); Peiyuan Qin (University of Technology Sydney, Australia); Jia Du (CSIRO, Australia)

In this paper, an innovative methodology for wideband multibeam conformal transmitarrays with arbitrary curvatures is presented for E-band applications. A unit cell composed of three metal layers is designed to support wideband phase tunable transmissions. A full phase tuning range of 360° is obtained at 74 GHz with the transmission loss lower than 2.3 dB. By employing the proposed methodology, two conformal transmitarrays with different curvatures are designed for different platforms. Both prototypes have been fabricated and measured. Multiple beams are achieved with angular ranges of ±30° and ±45° in wide 3-dB gain bandwidths of 30% and 27.8% for the two prototypes, respectively. Both of them have covered the entire E-band.

14:20 ***Miniaturized Wearable Antennas Using Resonant Current Path Length Manipulation***

Purna B. Samal (The University of Adelaide, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

This paper proposes a simple manipulation of the resonant current path length as a tool to miniaturize a microstrip-based wearable antenna. The operating frequency of the antenna is governed by the resonant current path length. As such, by electrically increasing the resonant current path length without changing the antenna size, the resonance frequency can be effectively decreased. The work demonstrates the introduction of two L-shape slots with total length of 10 mm to miniaturize a square microstrip antenna operating at 7.9 GHz. These slots electrically increase the resonant current path length by additional 20 mm, which decreases the resonance frequency by 2.1 GHz offering an antenna miniaturization of 27%.

14:40 *A Prototype of Helmet Antenna With Omnidirectional Radiation Pattern for VHF*

Taiyo Kai (National Defense Academy of Japan, Japan); Naobumi Michishita and Hisashi Morishita (National Defense Academy, Japan)

A novel helmet antenna using a disk-loaded monopole antenna is proposed. This helmet antenna operates at the very high frequency (VHF) band with omnidirectional and vertically polarized radiation pattern in the horizontal plane. Moreover, by loading an annular slit on the outer shell and an annular short on the edge of the inner and outer shell, this proposed antenna is reduced radiation toward the human head. The proposed antenna is prototyped and measured and compared with the simulated results.

15:00 *Cost-Effective Fully-Metallic Geodesic H-Plane Horn Antenna*

Mingzheng Chen (KTH Royal Institute of Technology, Sweden); Francisco Mesa (University of Seville, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

Geodesic lenses are proposed as a compelling solution for beamforming at high frequencies due to their advantageous properties of low cost and high efficiency. Actually, the concept of geodesics is a very useful framework with many applications in different fields. Here, we propose a geodesic H-plane horn antenna. The height profile of the horn antenna is modulated to alleviate the phase error and realize a directive beam. The simulation results show an enhancement of over 2.5 dB in realized gain of the geodesic horn antenna compared to a planar reference counterpart.

15:20 *Electrical Characterization of Pandanus Atrocarpus as a New Flexible Organic-Based Substrate: A Preliminary Studies*

Norlina Mohd Zain (Universiti Teknologi MARA Johor, Kampus Pasir Gudang, Johor, Malaysia); Mohd Aziz Aris (Universiti Teknologi MARA Terengganu, Malaysia)

The purpose of this study was to investigate potential the electrical characterization of mengkuang plants, scientifically named Pandanus Atrocarpus (PA), as a new flexible organic-based substrate in microwave communications. Moreover, there is a lack of published studies focusing on the organic-based dielectric substrates for flexible patch antennas. In this work, preliminary studies were conducted to investigate the utility of the dielectric properties of PA as a new organic-based substrate i.e. dielectric constant and tangent loss value are the most important elements for designing a patch antenna. The four PA samples were prepared based on the difference in drying time under the sun to measure the dielectric properties. These preliminary results show that the electrical characteristics of PA were investigated utilizing the PNA network analyzer and its specialized measuring instruments. This paper presents and discusses all of the experimental results.

RS8: Indoor and Outdoor Propagation

Room: C3.5

Chair: Takahiro Tomie (NTT DOCOMO, INC., Japan)

14:00 *Site-Specific Model of Building Entry Loss Based on Measurements in a High-Rise Building*

Shoma Tanaka (SoftBank Corp., Japan); Sho Kimura, Ho-Yu Lin, Akihiro Sato and Hideki Omote (Softbank Corp., Japan)

HAPS (High-Altitude Platform Station), which provides wireless communication services from an altitude of approximately 20 km using a balloon, an UAV (Unmanned Aerial Vehicle) or other aircraft, is attracting attention as a new mobile communication platform that that makes it possible to form an ultra-wide service area of around 200 km in diameter. In order to use HAPS to construct an efficient cellular network for wireless communication services, it is necessary to develop a radiowave propagation model that takes into account the factors of propagation loss such as the environment around the ground station, which includes terrain, vegetation, clutter, BEL (Building Entry Loss), and so on. In this paper, we clarify the characteristic of BEL based on measurements from outside to inside a high-rise building for various elevation and azimuth angles, indoor antenna heights and antenna positions. Furthermore, we propose a site-specific model of BEL.

14:20 *Performance Analysis of a Wireless Backhaul Network at Terahertz Frequencies*

Johannes M. Eckhardt, Christoph Herold, Bo Kum Jung and Thomas Kürner (Technische Universität Braunschweig, Germany)

In this paper, physical layer characteristics are analyzed for a wireless backhaul network in Berlin via ray-optical channel predictions and link-level simulations. Incorporating a mapping of the signal-to-interference-plus-noise ratio (SINR) to a modulation and coding scheme, the link level simulation provides the cumulative density

function of the SINR, bit error rate and effective data rate.

14:40 ***Improving Millimetre Wave Coverage in an Indoor Environment Using Passive Reflectors***

Priya Qualtrough Mittal (University of Auckland, New Zealand); Michael J Neve and Andrew C M Austin (The University of Auckland, New Zealand)

At millimetre wave frequencies, diffraction cannot be relied upon to provide coverage into non-line-of-sight regions, resulting in shadow regions formed behind obstacles. This paper investigates the use of passive planar and spherical reflectors to target coverage into shadow regions which may be formed by common obstructions (e.g. humans) in an indoor environment. It is observed that the use of curved reflectors increases the angular spread of reflected field components, at the cost of the amount of reflected power. It is also noted that the placement of a reflector needs to be carefully considered to achieve optimal coverage into a given shadow region.

15:00 ***Evaluation of Secret Transmission Performance of Spatially Selective Modulation***

Hiroto Yonawa, Hisato Iwai and Shinsuke Ibi (Doshisha University, Japan)

Spatially selective modulation (SSM) is a physical layer security technique based on multiple transmitting antennas and a single receiving antenna. The method allows only the legitimate receiver to receive the desired modulated signal correctly because of the location dependence of a wireless channel. Here, we analyzed the anti-eavesdropping performance of SSM when the separation of the transmitting antenna elements is changed.

15:20 ***A Study on Path Loss Prediction Based on Computer Graphics Technologies***

Takahiro Tomie, Satoshi Suyama, Koshiro Kitao and Mitsuki Nakamura (NTT DOCOMO, INC., Japan)

In this paper a method for path loss prediction in outdoor urban environment based on computer graphics technologies is presented. Each wall of buildings in an evaluation area is assigned to a different RGB color. We create two types of color images which viewed from a transmission point and receiving points. By analyzing and comparing the colors of these images, the visible colors from both sides corresponding to the single scattering walls are detected all at once. The numbers of pixels of the visible colors are used to calculate received powers of the single scattering waves. Comparison with measurement path loss result show that the prediction accuracy is high with RMSE of 7.6 dB. The computation time is extremely short.

Tuesday, November 1 15:40 - 16:10 (Australia/Sydney)

Afternoon Tea

Tuesday, November 1 16:10 - 17:50 (Australia/Sydney)

CS3-II: Recent advances in array antenna and metasurface engineering (Part II)

Room: C3.3

Chairs: Ikmo Park (Ajou University, Korea (South)), Gangil Byun (Ulsan National Institute of Science and Technology (UNIST), Korea (South))

16:10 ***Design of a Shared-Aperture Antenna With a Hashmark-Shaped Loop to Improve Electromagnetic Transparent Characteristics***

Doyoung Jang (Hongik University, Korea (South), Korea (South)); Sungsik Wang (Hanyang Cyber University, Korea (South)); Sangkeun Kim and DongYoon Kim (LIG Nex One, Korea (South)); Hosung Choo (Hongik University, Korea (South))

In this paper, we propose a shared-aperture antenna with a hashmark-shaped loop to improve electromagnetic (EM) transparent characteristics. The proposed antenna consists of one S-band element and 3x3 X-band elements with a dual loop structure. The S-band element has a hashmark-shaped loop, which can improve the EM transparent characteristics in the X-band without degradation of the antenna bandwidth. The measured fractional bandwidths in the S and X bands are 14.7% and 15%, respectively. The results demonstrate that the

proposed antenna is suitable for multi-function radar applications.

16:30 ***Generation of Plane Waves in the Nearfield Region in a Restricted Environment***

Hong Soo Park and Sun K. Hong (Soongsil University, Korea (South))

A wideband dual-polarized plane wave generator (PWG) based on an adaptive least squares (LS) for plane wave synthesis in a restricted environment is presented. Here we achieve plane wave synthesis at short distances with precision-limited weighting coefficients by applying an iteration limiting method to LS. The PWG performance is validated via numerical simulation. The results show that an adaptive LS provides weighting coefficients for synthesizing a stable plane wave even in a restricted environment compared to the general LS. This indicates that the proposed method is applicable to various PWG systems and realistic environments.

16:50 ***Millimeter-Wave Display-Mounted Antenna for Hand Gesture Sensing on Mobile Devices***

Jin Myeong Heo and Hae Soo Eun (Ulsan National Institute of Science and Technology (UNIST), Korea (South)); Haechan Chong (Ulsan National Institute of Science and Technology, Korea (South)); Gangil Byun (Ulsan National Institute of Science and Technology (UNIST), Korea (South))

In this paper, we propose a millimeter-wave (mmWave) printed-type antenna that can be mounted on display panel of mobile devices for hand gesture sensing. To be mounted on a narrow dead-zone in the display, the antenna has a thin strip. The antenna resonates between the adjacent strip and the ground slot, and it has a fractional impedance bandwidth of 12.3%. The simulated and measured results show that the proposed antenna can be utilized for hand gesture sensing by interfacing the antenna with a mmWave commercial radar module.

17:10 ***3D Tempered Glass-Covered Metasurface Antenna-In-Package Enabling Reliable 5G/6G Smartphone Beam Coverage***

Jaebaek Jung and Jungsuek Oh (Seoul National University, Korea (South))

This paper introduces a technology to improve beam coverage using tempered glass (provided by corning) used in commercial smartphone and a metasurface. In the proposed 3D Tempered Glass-Covered Metasurface Antenna-in-Package (MSAiP), tempered glass is covered on the AiP, and the metasurface is inserted between the AiP and the glass. The inserted metasurface is made through 2-port circuit modeling, and its physical size is small considering the narrow smartphone mounting space. In order to minimize the performance degradation caused by glass when AiP is mounted in a smartphone, performance optimization is carried out while AiP, metasurface, and glass are all combined. The peak gains of MSAiP are 13.5 dBi (27 GHz) and 13.1 dBi (38.5 GHz), whereas those of AiP without metasurface are 10.1 dBi (27 GHz) and 9.4 dBi (38.5 GHz). Besides, the peak EIRP (dBm)/tilting degree (°) of chip-coupled MSAiP are 6.59/0, 5.87/12, and 3.37/27. However, the results of chip-coupled AiP without metasurface are 2.01/0, 1.6/12, and -0.95/30. All these results indicate that beam coverage of AiP is improved by the inserted metasurface.

17:30 ***Analysis of AMC and EBG Properties in Planar Log-Periodic Toothed Antenna***

Donghyun Kim (Yonsei University, Korea (South)); Chan Yeong Park (Yonsei Universitiy, Korea (South)); Young Joong Yoon (Yonsei University, Korea (South))

In this paper, the radiation performance of the log-periodic (LP)-toothed antenna to which the meta-reflector is applied using AMC and EBG properties are analyzed and compared. A four-arm LP-toothed antenna is designed for electronic support measures (ESM) with a meta-reflector. AMC and EBG characteristics are investigated through different cells and the antenna performance is compared. The frequency response of the radiation performance is analyzed through the field distribution analysis and a suitable characteristic as a meta-reflector of the LP antenna is suggested.

CS5: Antenna Technology for Cellular and Satellite Communications

Room: C3.6

Chairs: Peng Mei (Aalborg University, Denmark), Shuai Zhang (Aalborg University, Denmark)

16:10 ***Ka-Band Implementation of a Geodesic Half Maxwell Fisheye Lens Antenna***

Shiyi Yang and Qiao Chen (KTH Royal Institute of Technology, Sweden); Francisco Mesa (University of Seville, Spain); Nelson Fonseca (European Space Agency, The Netherlands); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

In this work, a half Maxwell fisheye geodesic lens is proposed. This lens is used to produce a beam-scanning

antenna operating at Ka-band, suitable for 5G/6G and satellite communications. The proposed antenna has a wide beam coverage of 90° from -45° to 45° with scan loss below 3 dB, and a maximum gain of 24.3 dBi at 30 GHz. The size of this lens antenna is almost half that of a conventional Luneburg-Rinehart lens antenna.

16:30 ***Enabling Simultaneous Near-Field Focusing and Far-Field Radiation Using Multiple Lenses***

Peng Mei, Gert Pedersen and Shuai Zhang (Aalborg University, Denmark)

This paper introduces a methodology to design a scheme enabling simultaneous near-field focusing and far-field radiation by using multiple lenses. A large-size lens is designed to convert the spherical wave emanating from the feed source to a quasi-plane wave. A small-size lens is located at a parallel plane away from the large-size lens. By imposing proper phase shifts on the small-size lens, it can capture part of the electromagnetic waves from the large-size lens to achieve a focal spot in the near-field region of the small-size lens. The gain of the radiation beam and the intensity of the focal spot can be controlled by either adjusting the area ratio of, or the separation between the large- and small-size lenses. The simulations validate the effectiveness of the proposed methodology. The proposed scheme offers an alternative solution to achieve simultaneous near-field focusing and far-field radiation.

16:50 ***A Dual Band Resonant-Cavity Antenna for Satellite Communication***

Maira I Nabeel (University of Technology Sydney & NUST, Australia); Foez Ahmed (University of Technology Sydney, Australia); Muhammad Usman Afzal (School of Electrical and Data Engineering University of Technology Sydney, Australia); Dush Thalakotuna and Karu Esselle (University of Technology Sydney, Australia)

This paper demonstrates design of a dual-band resonant-cavity antenna (RCA) for satellite applications. The antenna can be used as base antenna for near-field meta-steering technology aimed at providing connectivity using low-earth-orbit satellite services. The notable feature of the presented RCA includes its planar profile and use of thin partially reflecting surface (PRS) for gain enhancement that can be designed for the antennas operating at any two frequencies within two operating bands. The design example presented here operates at 20 GHz and 27 GHz, where RCA peak directivity is 14 dB and 17 dB. The directivity can be increased by either using larger aperture or arraying copies of the proposed RCA.

17:10 ***A Compact Rectangular Loop Antenna for 5G mmWave Application***

DukSoo Kwon, Jung Hwan Hwang and Changhee Hyoung (Electronics and Telecommunications Research Institute, Korea (South)); Hyung Do Choi (ETRI, Korea (South))

The design and analysis of a compact rectangular loop antenna is presented. An application device requires an antenna with the desired radiation pattern to achieve the higher gain. However, when circuit elements for various functions are put in a small space, the radiation pattern is distorted due to the radiation leakage from the side lobe. The radiation-induced parasitic leakage path can cause loss in signal levels. We design the loop antenna to avoid the radiation leakage by adding the bypass current path. The proposed antenna can be used as a 5G mmWave application that receives a small quantity of electromagnetic wave while reducing the radiation leakage on the ground.

17:30 ***Effect of Directional Antenna Arrays on Millimeter Wave Cellular Networks***

Nor Aishah Muhammad and Norhudah Seman (Universiti Teknologi Malaysia, Malaysia); Nur Ilyana Anwar Apandi (Universiti Teknikal Malaysia Melaka, Malaysia)

The antenna pattern plays an important role in evaluating the performance of directional antenna array in wireless systems. This paper proposes an antenna approximation model to evaluate the coverage probability of uplink millimeter wave (MMW) cellular networks, where location of clustered users is modeled by a Poisson cluster process (PCP). Numerical results show that the proposed antenna model provides an accurate and tractable analysis than the existing antenna model.

OCS5: Planar Millimeter-Wave Antenna Arrays for Emerging Applications

Online Room A

Chairs: Fan Wu (Southeast University, China), Zhi Hao Jiang (Southeast University, China)

16:10 ***Millimeter-Wave Dual-Band Antenna Array Integrated in Metal-Framed Smartphones***

Xiaoyue Xia, Chao Yu, Fan Wu and Zhi Hao Jiang (Southeast University, China); Yu Yao (Huawei Technologies, China); Wei Hong (Southeast University, China)

In this work, a millimeter-wave (mmWave) dual-band phased array antenna is proposed for 5G/B5G smartphones. The configuration of the antenna array is integrated in the narrow metal frame of a smartphone. The proposed antenna contains a slotted frame and a cavity-backed antenna module. A prototype of the proposed 1×4 phased array assembled in a simplified metal frame is fabricated and measured. The antenna array achieves a -10-dB impedance bandwidth from 24.9-30.4 GHz and 35.5-40.7 GHz, covering 5G n257/260 band. And the phased array can obtain good scanning performance in the dual bands.

16:30 ***A 300 GHz SiGe Patch Antenna With 5.3 dBi Gain Using Off-Chip Package***

Sidou Zheng, Si-Yuan Tang, Xiaoyue Xia, Peigen Zhou, Jixin Chen and Wei Hong (Southeast University, China)

In this paper, a 300 GHz on-chip patch antenna with an off-chip package for gain enhancement in 130 nm SiGe BiCMOS is proposed. In this design, the bottom metal M1 and the top metal TM2 are employed as the ground and radiating patch respectively to enhance the bandwidth and gain. An off-chip metal block with an etched slot and an etched cavity is designed as a package for the antenna. The designed package helps to increase the antenna gain and stabilize the radiation pattern. The simulated results show the antenna has achieved a gain of 5.3 dBi at 300 GHz with the designed package, indicating an increase of 1.7 dB compared to the antenna in free space.

16:50 ***A Hybrid Dual-Polarized Conformal Dielectric Resonator Antenna Array for Mobile Terminals***

Yunli Li, Xiaoyue Xia, Fan Wu, Zhi Hao Jiang, Chao Yu and Wei Hong (Southeast University, China)

This paper presents a hybrid dual-polarized conformal dielectric resonator (DR) antenna (DRA) array for 5G millimeter wave mobile terminals. Each polarization has two resonant modes: the dielectric resonant mode and the slot mode. The combination of these resonant modes realizes wide impedance bandwidth (24.2-36.3 GHz) to cover 5G millimeter wave band n257 (26.5-29.5 GHz), n258 (24.25-27.5 GHz), and n261 (27.5-28.35 GHz). Besides, due to the flexible three-dimensional (3D) structure of DRs, the proposed antenna array can be adapted into the form of a phone frame. Thus, the proposed antenna can be conformably placed in the frame of the mobile terminal. In this design, the curved glass in the frame of the mobile terminal also works as an inherent portion of the DR. Therefore, the glass cover will not place a negative effect on the proposed antenna array as in conventional design approaches.

17:10 ***Development of Single-Layer Full-Corporate-Fed SIW Slot Array Antennas***

Miao Zhang and Zewei Li (Xiamen University, China); Baoquan Duan and Jiro Hirokawa (Tokyo Institute of Technology, Japan); Qing Huo Liu (Duke University, USA)

The single-layer full-corporate-fed SIW (Substrate-Integrated Waveguide) slot array antennas are developed in the 60-GHz band. Three 16×16-element arrays operating with different polarizations and aperture distributions are designed. The simulated results verify that wideband characteristics of input matching, high antenna gain, and high efficiency are realized over the frequency range of 57-66 GHz.

17:30 ***Design of mmW Broad-Beam Reflecting Surface Using Grey Wolf Optimizer***

You-Cheng Chen and Shih-Cheng Lin (National Chung Cheng University, Taiwan)

In this paper, a 28-GHz broad-beam planar reflecting surface (RS) is developed by optimizing the reflection phase distribution through the gray wolf optimizer (GWO) algorithm. The pattern mask is carefully determined for the cost function to achieve a satisfactory result. Specifically, the reflection phase distribution of RS composed of 35 × 35 unit cells with the 3-dB beamwidth of 30° is acquired. By applying the phase distribution to the RS, the calculation and full-wave simulated results in terms of normalized array patterns show good agreement, thus validating the adopted approach.

OS1: MIMO

Online Room B

Chair: Nobuyasu Takemura (Nippon Institute of Technology, Japan)

16:10 ***Broadband Diversity Antenna Array for UHF Digital TV***

Edson dos Santos (Mackenzie, Brazil); Daniel de Souza (Universidade Federal do ABC, Brazil); Marcelo B

Perotoni (UFABC, Brazil); Claudio J. Bordin, Jr. (Universidade Federal do ABC, Brazil); Marcos Vieira and Frank Smit (Mackenzie, Brazil); Cristiano Akamine (Universidade Presbiteriana Mackenzie, Brazil)

This article describes the design and test of a UHF broadband array antenna for applications in Digital Terrestrial TV Broadcasting (DTTB) TV 3.0 project covering the 470-700 MHz band. The antenna has two planar elements optimized for low mutual coupling to enable its use as a multiple-input multiple-output (MIMO) front end. The design was oriented towards easily manufacturing, broad bandwidth, and low cost. Measurement and simulation results confirm a low correlation coefficient between the elements as well as proper operation in the entire band.

16:30 ***A Study on Interference Suppression Performance Using Space Diversity of Mobile Terminal for Millimeter-Wave Full-Duplex MIMO System***

Nobuyasu Takemura (Nippon Institute of Technology, Japan)

In this paper, the authors proposed an interference suppression method using space diversity of mobile terminal for a millimeter-wave full-duplex MIMO system. As a method of terminal-to-terminal interference suppression, a technique using Eigen-beamforming is studied. Further interference suppression is realized by applying the space diversity technique to the mobile terminal when performing Eigen-beamforming. The effectiveness of this method is confirmed by millimeter-wave radio propagation simulation using the ray-tracing method in an outdoor environment.

16:50 ***A Dual-Slant-Polarized Differentially-Fed In-Band Full-Duplex (IBFD) Antenna***

Yuenian Chen (University of Technology Sydney, Australia); Can Ding (University of Technology Sydney (UTS), Australia); He Zhu and Y. Jay Guo (University of Technology Sydney, Australia)

In this paper, a dual-polarized antenna is developed with high isolation between its transmitting (TX) and receiving (RX) ports for in-band full-duplex (IBFD) applications. A square patch antenna with horizontal and vertical polarizations is adopted as the antenna element. A new self-interference cancellation (SIC) feed network is proposed to differentially feed the antenna and combine the horizontal/vertical polarizations into ±45° polarizations. By making use of the symmetry of the antenna configuration and differential feeding, the proposed network can cancel out the coupled and reflected signals, leading to high isolation between the TX and RX ports. A high isolation of 46 dB is realized within the working band from 3.31 to 4 GHz (18.5%) and the gain is above 7.5 dBi. In addition, across the operation band, the radiation patterns show a good stability with the frequency variation.

RS10: Inverse Scattering and Imaging Techniques

Room: C3.5

Chairs: David Powell (University of New South Wales, Australia), Hai-Han Sun (Nanyang Technological University, Singapore)

16:10 ***Radar Enhanced Contrast Source Inversion Method for Microwave Nondestructive Evaluation***

Katsuyoshi Suzuki (The University of Electro-Communications, Japan); Shouhei Kidera (University of Electro-Communications, Japan)

While radar imaging is one of the most promising approaches for microwave nondestructive evaluation of aging roads or tunnels, it could not retrieve a dielectric profile of a buried object, leading to difficulty in target identification. In this paper, we introduce a hybrid method by integrating the range points migration (RPM) radar imaging and the contrast source inversion (CSI) based inverse scattering to provide not only a location or shape of target, but also complex permittivity of it. The numerical and experimental data, assuming a real concrete road model, demonstrate the effectiveness of the proposed method.

16:30 ***Inverse Scattering Enhanced Synthetic Aperture Imaging for Multi-Layered Ground Media***

Yoshihiro Yamauchi (The University of Electro-Communications, Japan); Shouhei Kidera (University of Electro-Communications, Japan)

This paper introduces an accurate synthetic aperture radar method, enhanced by contrast source inversion method (CSI) based inverse scattering analysis for multi-layered subsurface imaging. In the proposed method, the SAR propagation model is determined by the Green's function in a heterogeneous background, that is optimized by the CSI process. The finite-difference time-domain (FDTD) based numerical tests show that our proposed method significantly enhances a reconstruction accuracy for objects buried in multi-layered ground medium.

16:50 ***Fundamental Study on Misclassification of Urban Areas in Scattering Power Decomposition for PolSAR Data***

Yuta Suzuki, Hiroyoshi Yamada and Ryoichi Sato (Niigata University, Japan)

The main objective of this paper is to improve the classification accuracy of PolSAR data for urban areas. In the PolSAR data decomposition method, the power of volume scattering often become dominant in urban areas due to orientation to the radar irradiation direction. In this paper, we examine the characteristics of the rotated covariance matrix in the oriented urban area where the volume scattering power is dominant, and propose a simple modification method to suppress the volume scattering power based on the characteristics of misclassified urban scattering component.

17:10 ***Diverse Beam-Generating Boundary Tunable Metasurface Antenna for Imaging***

Toufiq Md Hossain, David Powell and Andrey Miroshnichenko (University of New South Wales, Australia)

A novel boundary tunable planar metasurface antenna has been proposed for potential application in computational microwave imaging. The proposed antenna exploits the tunable switching arrangement of the via boundaries to create diverse beam patterns capable of capturing the scene information effectively. The superiority of the proposed antenna is validated by utilizing a semi-analytical model and analyzing the singular value decomposition of the field patterns in the scene plane compared with the previously reported frequency diverse approach.

17:30 ***Experimental Study on 3D Imaging Using Millimeter-Wave Non-Uniform 2D-MIMO Radar***

Tateki Kato and Hiroyoshi Yamada (Niigata University, Japan); Hiroki Mori (Toshiba Corporation, Japan)

The main objective in this study is to build a security system without stopping the flow of people at low cost. Most of the existing security systems use SAR (Synthetic Aperture Radar) processing to achieve highly accurate 2D or 3D imaging. However, SAR usually requires long observation time due to mechanical scanning. In this paper, we have developed a high-resolution millimeter-wave MIMO (Multiple-Input Multiple-Output) radar with non-uniform planar arrays for both transmitter and receiver, and evaluated the spatial resolution of the radar by experiments.

RS9: Decoupling and Inteference Suppression

Room: C3.4

Chair: Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain))

16:10 ***An Optimal Decoupling Selection for a Monopole Array on Finite Sized Ground Plane***

Shota Takato and Hiroyuki Arai (Yokohama National University, Japan)

To reduce the size of the antenna, we install the elements close to each other. It makes mutual coupling large and antenna characteristics worse. Therefore, several decoupling methods are reported to improve mutual coupling. However, comparison of each method in same conditions have not been reported. In this paper, we simulate monopole array on finite sized ground with each decoupling method and compare them. Finally, we select optimal decoupling method for monopole array and presents its characteristic.

16:30 ***Decoupling of Four Closely Spaced PIFAs Using Parasitic Elements and Bridge Lines***

Phung Quang Quan (National Defense Academy of Japan, Japan); Naobumi Michishita (National Defense Academy, Japan); Hiroshi Sato (Panasonic Corporation, Japan); Yoshio Koyanagi (Panasonic, Japan); Hisashi Morishita (National Defense Academy, Japan)

This study proposed a simple decoupling method for four planar inverted-F antennas (PIFAs) operating at 2.0 GHz (f0) using parasitic elements (PEs) and bridge lines (BLs). The edge-to-edge spacings of the adjacent PIFAs is extremely small, resulting in strong mutual coupling among them. The simulated results showed that loading the proposed PEs and BLs onto the four PIFAs could reduce as well as maintain all mutual coupling for less than -10 dB, which are acceptable levels for MIMO antennas, and simultaneously improve impedance matching. Therefore, the total antenna efficiency at 2.0 GHz could be significantly improved from 64.2% to 84.8% for PIFA1 and PIFA4 and from 35.9% to 74.2% for PIFA2 and PIFA3.

16:50 ***Closely Spaced MIMO Dielectric Resonator Antenna for Sub 6 GHz Applications***

Mohammad Abedian (University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); Pei Xiao (University of Surrey, United Kingdom (Great Britain)); Yasin Kabiri (Huawei Technologies Sweden, Sweden); Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))

A simple-structure probe-fed multiple-input multiple-output (MIMO) dielectric resonator antenna (DRA) is designed for sub-6GHz applications with a reduced inter-element spacing (< 0.5λ). A 4-element rectangular DRA is positioned in a compact space verifying the proposed DRA potential for MIMO applications. Each element consists of two dielectric resonators with different permittivity of 5 and 10, excited by the coaxial probe. The measurement results reveal that the proposed MIMO DRA provides an envelope correlation coefficient (ECC) of less than 0.01 with good MIMO performance.

17:10 ***Robust Beamforming for Space-Based SAR Phased Arrays With Distributed Interferer Suppression***

Jiahao Wang and Koen Mouthaan (National University of Singapore, Singapore)

Phased arrays find application in space-based synthetic aperture radars (SAR). Beamforming can be used in these phased arrays to receive desired radar returns and to suppress unwanted returns and interfering signals. Usually, the number of interferers and their location is not known or may vary. Also, the distance from interferers to the SAR varies. Here, a new robust beamforming algorithm is proposed to deal with the case when the interferers are distributed with a specific distribution. This algorithm is applied to a satellite communication case study, compared with the equi-sidelobe beamformer then shows the results.

17:30 ***A Novel Radiation Cancelling Filtering Dielectric Resonator Antenna Based on AMC Surface***

Bing Zhang, Wen Li, Jian Ren and Ying Zeng Yin (Xidian University, China)

Wednesday, November 2

Wednesday, November 2 8:30 - 10:10 (Australia/Sydney)

CS6: Emerging Metasurface Technologies for Antenna Applications

Room: C3.3

Chair: Hiroshi Hashiguchi (National Defense Academy, Japan)

8:30 ***A Low-Profile Direction-Finding Antenna With Deep Null Steering Using High-Impedance Surface***

Jo Tamura and Hiroyuki Arai (Yokohama National University, Japan)

This paper proposes a null-steering antenna that scans a deep null without controlling the amplitudes of the antenna elements. The proposed antenna comprises two dipole antennas and a reflector made by a high-impedance surface (HIS). The antenna characteristics are compared to a conventional patch antenna array to demonstrate that the proposed one is more suitable for a direction-finding antenna. The study clarifies that the HIS makes the antenna height as low as the patch antenna and null depths greater than −30 dB within ±70°. The antenna can be potentially integrated into simple and accurate direction-finding systems due to its compactness and excellent scanning performance at a low cost.

8:50 ***A Metamaterial-Inspired V-Shaped Wire Antenna for Wideband Operation***

Weiyi Chen, Koji Asakawa, Hiroyuki Kurosawa and Tetsuya Ueda (Kyoto Institute of Technology, Japan)

In this paper, a V-shaped wire antenna periodically loaded with lumped capacitors to construct zeroth-order resonators is proposed for wideband operation. The numerical simulation results show the operating band for a reflection loss below -10.0 dB ranging from 2.89 GHz to 5.99 GHz, and the fractional bandwidth of 69.9% is achieved.

9:10 ***Effective Modeling Method of Single Antenna Above Meta-Surfaces in FDTD Method***

Takuji Arima (Tokyo University of Agriculture and Technology, Japan); Toru Uno (Tokyo University of Agricultural Technology, Japan)

Metamaterials including meta-surfaces are artificial structures which size smaller than the wavelength. The Metamaterials are widely developed for commercial use. Especially, meta-surfaces such as EBG and AMC are

often utilized in antenna engineering fields. The numerical analysis method as an FDTD method is widely used. However, calculation cost of the FDTD method becomes huge due to the complex structure of the met-surfaces. In this research, an effective modeling methods are indicated. The methods utilize surface impedance boundary condition (SIBC) and ASM-FDTD method.

9:30 ***A Meta-Surface-Inspired Circularly Polarized Antenna With Magneto-Electric Feeding Structure***

Ryuji Kuse, Kosuke Tsushima and Takeshi Fukusako (Kumamoto University, Japan)

This paper presents a meta-surface-inspired antenna with magneto-electric features to reduce the antenna height and achieve low cross-polarization. An advantage of the antenna is that the proposed antenna has a simple design. I addition to this, the proposed antenna has stable gain characteristics of RHCP in the frequency band ranging from 8.2 GHz to 10.2 GHz with a good impedance matching and low-cross polarization in a wide azimuth range.

9:50 ***Analyses of Transmission Loss of a Gap Waveguide Composed of a Dielectric Substrate With EBG Elements***

Yuichi Kimura, Toshiki Kajie and Sakuyoshi Saito (Saitama University, Japan)

This paper presents transmission loss characteristics of a gap waveguide composed of a dielectric substrate with EBG elements. The proposed gap waveguide consists of a top conductor plate, a bottom dielectric substrate with mushroom-like EBG elements, and an air layer between them. EBG elements prevent a leakage from the gap waveguide in the air layer and can be manufactured cost-effectively with PCB processes. Transmission loss of the gap waveguide is analyzed by numerical simulation with ANSYS HFSS at 4.7 GHz. It reveals by the simulation that smaller transmission loss of the gap waveguide of less than 1 dB/m is obtained for the cases of a large distance of the EBG elements, a large width of the ridge conductor, and a small height of the air layer in comparison with a microstrip line with the same dielectric substrate.

CS9-I: Latest Technologies for advanced antenna and measurement systems (Part I)

Room: C3.6

Chairs: Takashi Tomura (Tokyo Institute of Technology, Japan), Toru Fukasawa (Mitsubishi Electric Corporation, Japan)

8:30 ***Simplified OTA Test Using Phase-Less Spherical Near Field***

Yusuke Mitsui and Hiroyuki Arai (Yokohama National University, Japan)

This paper presents a far field estimation method for a small low-gain antenna using a phase-less spherical near field to reduce the measurement facility size and measurement time used in the far field measurement. The proposed method is phase-less near field measurement by introducing three novel techniques such as the method of forming approximated wire grid model of the antenna, optimal matrix calculation, and near field measurement. We obtained high accuracy far field estimation by introducing the proposed method, which is verified in simulation.

8:50 ***Element-Level Electric-Field Measurement of Phased Array Antennas Using Electro-Optic System for mm-Wave 5G Communications***

Young-Pyo Hong, No-Weon Kang and Dong-Joon Lee (Korea Research Institute of Standards and Science, Korea (South))

This paper proposes an improved electric-field measurement method for phased array antenna calibration. For free space calibration of array antenna, the complex excitation coefficients for each antenna is determined from the measured amplitude and phase data, and each individual element can be individually compensated for to correct the amplitude and phase errors. A highly stabilized planar field imaging system with dual electro-optic sensors is developed to measure the phase in the reactive near-field region of an array antenna. Experimental results of the electric field of an array antenna operating at 28 GHz are shown to validate the performance of the proposed electro-optic system.

9:10 ***Radiation Characteristics of Wideband Skeletal Discone Antenna***

Achmad Munir (Institut Teknologi Bandung, Indonesia); Rheyuniarto Sahlendar Asthan (Institut Teknologi Sumatera, Indonesia); Zulfi Zulfi (Institut Teknologi Bandung, Indonesia)

This paper presents the development of skeletal discone antenna and its radiation characteristics investigation. The proposed antenna is intended to work in wide bandwidth, in particular, to cover the frequency of 700 MHz suitable for wireless communications. The disc part of the proposed antenna is implemented by a copper sheet with the diameter of 73 mm, while the cone part is developed by a number of thin copper wires with the length of 110.5 mm to construct the antenna body. The results of radiation characteristics investigation show that the proposed configuration of skeletal discone antenna has a wide fractional bandwidth up to 130% with the lowest operating frequency of 686 MHz and acceptable matching impedance. In addition, stable omnidirectional patterns can be maintained within operating bandwidth at the corresponding frequency of 0.92 GHz and 2.4 GHz.

9:30 ***Cylindrical Near-Field Scanning of Bistatic Radar Cross Section for Reflectarray With Two-Dimensional Reflection***

Hiroshi Hashiguchi, Naobumi Michishita and Hisashi Morishita (National Defense Academy, Japan); Hiromi Matsuno and Takuya Ohto (KDDI Research, Inc., Japan); Masayuki Nakano (KDDI Research, Japan)

This paper presents cylindrical near-field scanning of bistatic radar cross section for reflectarray. In 5G mobile communication, the reflectarray has gained attention for reducing the coverage holes which no link from base station to the receiver. The reflectarray is evaluated by the bistatic radar cross section (RCS). To evaluate the performance of such a reflectarray, the two-dimensional bistatic RCS measurement is required. The reflectarray is measured in near-filed and cylindrical scanning, which is like the simulation result.

9:50 ***Improvement of Target Estimation Accuracy of Terahertz Reflection Time-Domain Spectroscopy With MUSIC Using Virtual Arrays***

Keisuke Kobayashi (Graduate School of Engineering, Chiba Institute of Technology, Japan); Keizo Cho, Hiroaki Nakabayashi and Koji Suizu (Chiba Institute of Technology, Japan)

In reflective THz-TDS imaging using virtual arrays (VAs) in the synthetic aperture array (SAA) algorithm, the location of VAs would affect the target position estimation accuracy. This abstract first shows the influence of the distance between the VA and target. Then, to improve the accuracy without increasing the SAA elements, a method using multiple frequency images is investigated, which is suitable for this measurement system because THz-TDS uses pulse signals. The effectiveness is confirmed by simulation and measurement.

RS11: Localization and Remote Sensing

Room: C3.4

Chair: Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia)

8:30 ***Design of a Single Radiator Monopulse Antenna for UWB Direction Finding***

Sangwoon Youn (Hongik University, Korea (South)); Byung Jun Jang (Kookmin Univ, Korea (South)); Hosung Choo (Hongik University, Korea (South))

This paper proposes the single radiator multi-port antenna with a slot-coupled feeding structure that can estimate the direction of arrival without using multiple array elements. The proposed single patch radiator with a director, which can obtain a high gain characteristic, replaces the multiple array elements. The slot-coupled feeding structure is designed to achieve broadband characteristic in the frequency range of 7 GHz to 9.8 GHz. Then, to observe the direction finding performance, the monopulse ratio which does not require time synchronization is obtained with a root-mean-square error of 0.02.

8:50 ***Simultaneous Estimation of Walking Occupant Location and Stationary Occupant Respiratory Rate Using Millimeter-Wave Radar***

Takayuki Kitamura, Isao Matsushima and Satoshi Kageme (Mitsubishi Electric Corporation, Japan)

This study presents a novel method for simultaneously estimating walking occupant locations and stationary occupant respiratory rates in an indoor environment using millimeter-wave (MMW) radars. A combination of range-Doppler processing and digital beamforming was used to distinguish moving objects from stationary objects, and locate them separately. The arctangent demodulation method and vital sign reliability calculation were used to estimate the respiratory rate of the stationary occupant with the highest vital sign reliability. The experimental results obtained using a multiple-input multiple-output (MIMO) radar showed that the proposed method could accurately estimate the location and respiratory rate of an occupant at rest, and the location of an occupant walking without any false detections.

9:10 ***Study on Roll Angle Estimation of Radar Target Using Null Beam and Rotation Matrix***

Yoshiki Takahashi (Mitsubishi Electric Corporation, Japan); Ryuhei Takahashi (MitsubishiElectricCorporation, Japan)

In recent years, the role of radar has become more than just a basic function such as detection and tracking. An example of multi-functionality is the estimation of target shapes. To solve this problem, in a previous study we proposed an angle spread estimation method that is computationally efficient. However, the accuracy of this method is affected by the roll angle of the radar target. In this study, we propose a roll angle estimation method using a null beam and a rotation matrix.

9:30 ***Distance Detection to a Human Body in a Sensing Technique Based on Changes of Antenna Characteristics***

Shintani Kazuki (Doshisha University, Japan); Satoru Shimizu (ATR, Japan); Koudai Nagatomo, Hisato Iwai and Shinsuke Ibi (Doshisha University, Japan); Takuya Kurihara and Toshikazu Sakano (Advanced Telecommunications Research Institute International, Japan)

9:50 ***Simultaneous L/X Prime Focus (F/D=0.41) Feed System for Remote Sensing Application***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia)

The design of a simultaneous L/X receive-only prime-focus feed system for a parabolic reflector with an F/D ratio of 0.41 is presented. A couple of options are given depending on the requirements for the L-band feed network.

RS12: Antennas for Medical Applications

Room: C3.5

Chairs: Konstanty S Bialkowski (The University of Queensland, Australia), Kamilia Kamardin (Universiti Teknologi Malaysia, Malaysia)

8:30 ***Noncontact Size Detection Method for Bedsores***

Yusuke Asano (Chiba University, JAPAN); Masaharu Takahashi (Chiba University, Japan)

Bedsores are injuries caused by prolonged pressure on the skin and stagnation of blood flow. The more the damage caused by bedsores progresses, the longer the treatment period becomes. Moreover, patients require surgery in some cases. Therefore, early detection is essential. In our research we are developing a noncontact bedsore detection system using electromagnetic waves at 10.5 GHz. In this paper, we extracted appropriate information from a scalogram and utilized it to detect the sizes of bedsores.

8:50 ***Dynamic Heart Phantom for Electromagnetic Imaging***

Cheng Chen and Konstanty S Bialkowski (The University of Queensland, Australia)

9:10 ***Development of a Numerical Model of 60 GHz Band Lens Antenna for the Study of Thermo-Physiological and Cellular Function Changes Induced by Millimeter-Wave Exposure***

Kohei Yamamoto and Takashi Hikage (Hokkaido University, Japan); Hiroshi Masuda (Kurume University School of Medicine, Japan); Tatsuya Ishitake (Kurume University, Japan); Kun Li (Kagawa University, Japan); Akiko Nagai (Aichi Gakuin University, Japan)

In order to study thermo-physiological reactions and changes in cellular functions induced by millimeter-wave exposure, a numerical model of a large-diameter dielectric lens antenna that constitutes a 60 GHz exposure system was developed and its exposure characteristics were evaluated through numerical analysis. It was confirmed that a higher exposure intensity can be achieved in a desired spot area on a phantom that simulates human skin compared to a conventional model.

9:30 ***Electrical Performances of Meander Line Antenna in Fat Phantom***

Ngu War Hlaing (MJIIT & UTM, Malaysia); Kamilia Kamardin (Universiti Teknologi Malaysia, Malaysia); Yoshihide Yamada (Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, USA); Takuji Arima (Tokyo University of Agriculture and Technology, Japan); Masaharu Takahashi (Chiba University, Japan); Naobumi Michishita (National Defense Academy, Japan)

The meander line antenna (MLA) was employed at small size antenna applications. To obtain high antenna efficiency, the self-resonant structure was important. In this paper, the electrical performances of MLA is clarified. Through electromagnetic simulations, the self-resonant structure, input impedance, VSWR characteristics are obtained. In order to measure electrical performance, human body phantom of fat tissue is fabricated. At the condition of MLA inside the phantom, input impedance and VSWR characteristics are measured. Good agreement of calculated and measured results are ensured.

9:50 ***Small Loop Shape Antenna for Generating a Localized Heating Region***

Tsugumi Nishidate and Kazuyuki Saito (Chiba University, Japan)

Microwave energy devices can coagulate biological tissues without generating surgical smoke. Therefore, we proposed the double-loop shape antenna for miniaturization and generating a localized heating region to adapt microwave energy device for robotic surgery. In order to evaluate the heating characteristics, numerical analysis and heating experiment were calculated. As a result, it is confirmed that the double-loop shape antenna with 10 mm rod can generate uniform heating region.

Wednesday, November 2 10:10 - 10:35 (Australia/Sydney)

Morning Tea

Wednesday, November 2 10:35 - 12:40 (Australia/Sydney)

IS3: Invited talk session 3：Advanced Electromagnetic Techniques

Room: C3.3

Chair: Zhongxiang Shen (Nanyang Technological University, Singapore)

1. 10:35 - Millimeter-wave antennas and their interactions with users for 5G mobile terminals

Shuai Zhang (Aalborg University, Denmark)

2. 11:00 - Characteristic Mode Analysis for Reconfigurable Antennas on Complex Platforms

Simone Genovesi (Pisa University, Italy)

3. 11:25 - Geodesic Lens Antennas for 5G/6G and Satellite Communications

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

4. 11:50 - Electromagnetic Medical Imaging- Challenges and Opportunities

Amin Abbosh (The University of Queensland, Australia)

5. 12:15 - On-Chip Antennas: The Last Barrier to True RF System-on-Chip

Atif Shamim (King Abdullah University of Science & Technology, Saudi Arabia)

IS4: Invited talk session 4：Metasurface and Beamforming Techniques

Room: C3.6

Chair: He Zhu (University of Technology Sydney, Australia)

1. 10:35 - Achieving Hemispherical Beamscanning Using Double-Boundary Radomes for Millimeter-Wave Communication and Radars

Wonbin Hong (Pohang University of Science and Technology, Korea)

2. 11:00 - Beam Manipulations of Reconfigurable GeTe Metasurface for Terahertz Frequencies

Steve Hang Wong (City University of Hongkong, Hongkong)

3. 11:25 - Space-Time Coding Metasurface

Qiang Cheng (Southeast University, China)

4. 11:50 - From Phase-Mode Antenna to the Generalized Principle of Pattern Multiplication-1D Array to 2D Scanning

Junping Geng (Shanghai Jiaotong University, China)

5. 12:15 - Array Antenna Beamforming Technique Using Maximum Power Transfer Condition of MIMO-WPT system

Qiaowei Yuan(Tohoku Institute of Technology, Japan)

Wednesday, November 2 12:40 - 14:00 (Australia/Sydney)

Lunch

Wednesday, November 2 14:00 - 15:40 (Australia/Sydney)

CS7: Advances in Computational electromagnetics and its application

Room: C3.3

Chairs: Takuji Arima (Tokyo University of Agriculture and Technology, Japan), Takashi Hikage (Hokkaido University, Japan)

14:00 *Propagation Loss Characteristics Considering Human Body Shadowing in Local 5G Frequency Band Using Parallel FDTD Analysis*

Kazuki Yoshida, Takashi Hikage, Manabu Yamamoto and Manabu Omiya (Hokkaido University, Japan)

This study focuses on propagation characteristics of local-5G frequency bands, including the human body shadowing in indoor environments. We modeled an indoor propagation environment assuming a small conference room containing humans and evaluated the propagation loss characteristics using a large-scale 3D numerical analysis based upon the FDTD method. The electric field distribution in the conference room is excited by a 4.7 GHz transmitting antenna, which is used as the local-5G access point, was calculated, and the propagation characteristics with and without the human bodies were compared. Shadowing and scattering effects due to multiple precise, realistic human bodies in standing and sitting postures were evaluated in the full-wave simulations.

14:20 *DCNN-Based Multipath Channel Prediction Model in Mobile Communication Environment*

Kazuki Takahashi (Tokyo Denki University & Engineering, Japan); Tetsuro Imai (Tokyo Denki University, Japan); Miyuki Hirose (Tokyo Denki University & Kyushu Institute of Technology, Japan)

Nowadays, the next generation mobile communication systems (Beyond 5G / 6G) have been actively investigated

all over the world, and we have proposed the radio propagation loss prediction model with deep convolutional neural networks (DCNN) to improve the prediction accuracy. In our model, the features which needed for propagation loss prediction are automatically extracted from image maps. So, it is expected that our proposed model can also predict multipath channels. In this paper, we extend our proposed DCNN-based model to multipath channel prediction and clarify its performance.

14:40 ***Doppler Shift Analysis of Moving Antennas Above the Road Surface by Using FDTD Method***

Takuji Arima and Naoki Ariyama (Tokyo University of Agriculture and Technology, Japan); Ryo Yamaguchi (SOFTBANK Corp., Japan); Kazuma Tomimoto (Softbank Corp., Japan); Toru Uno (Tokyo University of Agricultural Technology, Japan)

In this study, a method to analyze the Doppler shift of vehicles running in line by FDTD method is proposed. The electromagnetic wave is radiated from antennas mounted on a moving vehicle, then, strong reflected wave from road surface is received by RX antenna. Therefore, Doppler shift is observed. In this paper, Doppler shift at 30 km/h in speed were analyzed. The frequency analyzed in this paper is 79 GHz. In the propagation characteristics, the Doppler shift characteristics of the radio waves reflected from the road surface and the vehicle are clearly shown.

15:00 ***Far Field Analysis by MR/FDTD With Adaptive Integration Method***

Kei Asahi and Takuji Arima (Tokyo University of Agriculture and Technology, Japan)

With the widespread adoption of telecommunication devices such as smartphones, the importance of numerically simulating the environments where such devices are typically used (e.g. cities) had increased over the recent years. Simulating such environments typically requires large-scale models. The Finite-Difference Time-Domain (FDTD) method is a widely used numerical electromagnetic simulation method. However, this method is typically not suited for simulating large-scale models. The Multiple-Region (MR) FDTD method addresses some downsides of the FDTD method. However, its calculation speed can still be slow. In this letter, calculation speed optimization method for the MR/FDTD is proposed and verified through simulations.

15:20 ***An Efficient Method for Analyzing the Wideband RCS of Multi-Scale Objects Based on SAIM and CAT***

Haoxuan Gong, Hairong Zhang, Chunheng Liu, Ying Liu, Xing Wang and Tingchang Shan (Xidian University, China)

The subdomain adaptive integral method (SAIM) in conjunction with the Chebyshev approximation technique (CAT) is utilized to efficiently analyze the wideband radar cross section (RCS) of multi-scale objects in this paper. The SAIM can divide the whole object into several subdomains, each of which can be independently solved with AIM. The CAT is employed to expand the current coefficients at a small number of Chebyshev frequency sampling points to any frequency point over the entire desired frequency band. In addition, the application of the Maehly approximation can improve the computational accuracy. Numerical examples show that the proposed SAIM-CAT can greatly reduce the computation time without loss of accuracy.

CS9-II: Latest Technologies for advanced antenna and measurement systems (Part II)

Room: C3.6

Chairs: Jiro Hirokawa (Tokyo Institute of Technology, Japan), Toru Fukasawa (Mitsubishi Electric Corporation, Japan)

14:00 ***One-Port Calibration Methods Applicable to Free-Space Material Measurement***

Jin-Seob Kang (KRISS, Korea (South))

Accurate and precise measurement of the scattering parameters of a material under test (MUT) is essential for enhancing the measurement uncertainty of material parameter measurement of the MUT. Two one-port calibration methods applicable to a free-space one-port material measurement are described, and their measurement results are compared with those obtained from the two-port TRL method for a glass plate in W-band.

14:20 ***Design of Millimeter-Wave Antenna for Compact Antenna Test Range (CATR)***

Sarinya Pasakawee (National Institute of Metrology Thailand, Thailand); Vitawat Sittakul (King

Mongkut's University of Technology North Bangkok, Thailand)
This paper proposes a novel millimeter-wave antenna for compact antenna test range (CATR). The antenna is designed for millimeter-wave (mmWave) and can be used as a high gain omnidirectional with array configuration. The measurement results show that the 2x2 array antenna can be operated at the frequency around 27.5-29 GHz with a gain of approximately 2 dBi as well as omnidirectional capability.

14:40 ***High-Precision Measurement of the Radiation Patterns of Small Antennas by an S-Parameter Method Using a Photodiode Module***
Shimpei Akimoto (Mitsubishi Electric Corporation, Japan)
This paper proposes an S-parameter method using a small PhotoDiode module for improving precision of radiation pattern measurement. The effects of structure for measurement are reduced compared to the measurement system with the conventional method by using the RF cable of the minimum necessary length and the PhotoDiode module. We verify the effectiveness of the proposed method by the measurement of a small bent monopole antenna.

15:00 ***Antenna and Propagation Measurements for Next Generation Mobile Communications***
Ryo Yamaguchi (SOFTBANK Corp., Japan); Kazuma Tomimoto (Softbank Corp., Japan)
Antenna and propagation measurement technologies for next-generation mobile communications are reviewed, and the radio control VNA system for V2V and the vehicular MIMO antenna evaluation system are introduced as examples of measurement systems developed.

15:20 ***A Test of Measurement of Antenna Alignment Using Image Processing***
Yuanfeng She (National Institute of Advanced Industrial Science and Technology, Japan)
This paper introduced a simple position tracing system with the image processing technology to measure the uncertainty due to the antenna misalignment in the extrapolation method. The antenna alignment has been traced in the extrapolation by the camera. The uncertainty due to the misalignment can be evaluated quantitatively in the measurement.

OS2: Sensing and Imaging

Online Room A

Chair: Nghia Nguyen-Trong (University of Adelaide, Australia)

14:00 ***An Rx Selection for Reducing Spatial Variation in TOA Localization Accuracy***
Takeshi Amishima (Meiji University, Japan)
In this paper, we propose a method to select a set of receiving stations (Rxs) from multiple Rxs candidates in a certain monitoring area for the Time Of Arrival (TOA) localization. This proposed method focuses on the fact that the TOA localization accuracy varies depending on the position of the Rxs. We propose a Rxs selection method based on distances between Rxs so that the Rxs are selected evenly. In addition, to tackle the problem that the accuracy deteriorates at the contour of the monitoring area, we propose a method to prioritize the Rxs at the contour of the monitoring station as well. By simulation, we show the effectiveness of the proposed method.

14:20 ***Bistatic Millimeter-Wave Imaging Using Leaky-Wave Focusing Antennas***
Hiroyasu Sato (Tohouku University, Japan)
In this paper, an active millimeter wave-imaging system is proposed where detection of a target object is achieved by measurement of both the scattered and reflected fields. In the proposed system, two leaky-wave focusing antennas (LWFAs) are deployed in a bistatic setup and the capability of the proposed setup to detect and subsequently image a planar conducting target object is verified by measurement. It is shown that the object can be detected and the geometrical characteristics can be more clearly distinguished in the image generated from the reflected field.

14:40 ***Flexible Biosensor for Non-Invasive Continuous Alcohol Monitoring***
Qian Wang (University of Electronic Science and Technology of China, China)
In this paper, we introduce an inexpensive, lightweight, high-sensitivity, and long-life passive wearable biosensor for wireless non-invasive continuous monitoring of alcohol concentration in biofluids. The sensor consists of a

stretchable inductor with a symmetric serpentine structure and a circular interdigitated capacitor to form an resistor-capacitor-inductor (RCL) resonant circuit. The alcohol concentration change modifies the environmental dielectric constant of the capacitor and consequently the resonant frequency of the RCL circuit, which can be measured wirelessly with a primary coil. Both high-frequency structure simulator (HFSS) simulations and experiments verify the dependence of the resonant frequency on the alcohol concentration in the alcohol/water mixture. In vivo and in vitro experiments with pigskins validate the good sensitivity of the device and its feasibility in continuous monitoring of alcohol concentration in biofluids. Continuous non-invasive monitoring of alcohol concentration may open a new avenue for future flexible wearables and smart medicine.

15:00 ***Attributed Scattering Center Extraction With Improved Orthogonal Matching Pursuit***

Guopeng Peng, Chunheng Liu, Jiahui Wu and Yuxiang Zhou (Institute of System Engineering, China); Xing Wang and Jinyong Hou (Xidian University, China)

The attributed scattering center extraction is aimed to solve a high-dimensional, and highly nonlinear problem, which generates high complexity and memory requirements. To alleviate this difficulty, this paper proposes an attributed scattering center extraction method with improved orthogonal matching pursuit (OMP). Local optimization orthogonal matching pursuit (LOOMP) and alternative optimization are utilized to estimate parameters and reduce the dictionary dimension. Experimental results show that the proposed method outperforms the existing frequency-domain method in terms of runtime and memory requirements.

15:20 ***Reflected Slow and Fast Wave Attenuation Association With Cancellous Models Porosities and Thicknessess***

Muhamad Amin Abd Wahab and Rubita Sudirman (Universiti Teknologi Malaysia, Malaysia); Nasrul Humaimi Mahmood (UTM, Malaysia); Mohd Azhar Abdul Razak and Syarifah Noor Syakiylla Sayed Daud (Universiti Teknologi Malaysia, Malaysia)

Assessment of bone condition using ultrasound based on pulse echo (PE) technique is preferred because the usage of single transducer. The objective of this paper is to conduct an experiment using PE technique to examine the correlation of fast and slow wave attenuation with various porosities of polyurethane (PU) foam. The waves are decompose using bandlimited deconvolution methods. It observed that the fast wave required sufficient thickness of solid structure to interact well. Despite suffer interference with unwanted scattered wave, the reflected fast and slow wave which propagates twice through the bone models and have enough interaction with the internal structure may contribute to the moderate and constant correlation coefficient for every thickness (fast wave, R2average = 0.58 and slow wave, R2average = 0.70).

OS3: Reflection/Transmission Arrays

Online Room B

Chair: Yue Li (Tsinghua University, China)

14:00 ***The Design of a Dual-Band Bidirectional Metal-Only Transmit-Reflected-Array Antenna Element With Different Polarizations***

Min Wang and Yuxin Mo (Chongqing University of Posts and Telecommunications, China); Zhengchuan Chen (Chongqing University, China)

In this paper, a dual-band bidirectional metal-only transmit-reflected-array antenna (TRA) element with different polarizations is designed by etching slot in square metal sheet. The proposed metal-only TRA element is composed of two split-ring slots with different radius and four triangular slots with T-shaped branches. And the proposed TRA element can be utilized to tune phase for circularly polarized (CP) wave at 10.0GHz, and for linearly polarized (LP) wave at 22.0 GHz. In the lower frequency band, the large split-ring slot is regarded as the main radiation structure, which tune the phase by rotating the large split-ring. In the higher frequency band, the combination of the small split-ring slot and four triangular slots with T-shaped branches is regarded as main radiation structure by varying the length of the branches and flipping the small split-ring along the y-axis to tune the phase. Finally, the simulated results show that the proposed TRA element has the same reflected and transmitted performance under the same incident conditions, and the phase coverage of 360° and 330° with low losses is obtained at 10.0 GHz and 22.0 GHz, respectively.

14:20 ***A New Low-Cost and High-Gain Dual-Band Reflection/Transmission Array Antenna***

Chi Zhang, Qian Lu and Ying Yu (Nanjing University of Posts and Telecommunications, China)

In this paper, we propose a new array antenna that can work in reflection and transmission modes

simultaneously or separately. Reflection and transmission at two frequencies are realized by designing better frequency selective surfaces (FSS) for the antenna. An antenna array including 14 × 14 elements and fed through a horn antenna is designed and simulated. The peak gain is 26.8 dB when the array is operated in reflection mode at 12 GHz and 21.7 dB in transmission mode at 7 GHz.

14:40 ***A 1-Bit 14 × 14 Dual-Beam Electronically Reconfigurable Reflectarray***

Qian Lu, Ruozhou Li and Ying Yu (Nanjing University of Posts and Telecommunications, China)

An element is proposed in this paper which is composed of two trapezoidal patches and one PIN diode. The 180° phase difference can be achieved by tuning the working states of PIN diode. Utilizing the proposed element, a dual beam reconfigurable reflectarray antenna (RRA) is designed. The RRA is simulated in Ansys HFSS 15 and the full-wave simulations show a good beam-scanning of the reflectarray antenna. Symmetrical and asymmetrical, equal and unequal amplitude dual beams scanning can be obtained by changing the reflection phase.

RS13: V2X and IoT

Room: C3.4

Chairs: Wang-Sang Lee (Gyeongsang National University (GNU), Korea (South)), Pei Xiao (University of Surrey, United Kingdom (Great Britain))

14:00 ***Miniaturized UHF Module-Integrated Antenna With RF-Based Detection for Multi-Objective UAV Applications***

Jeong-Su Park, Min-Seong Kim and Wang-Sang Lee (Gyeongsang National University (GNU), Korea (South))

In this paper, we propose a system with a miniaturized antenna structure in the 915 MHz band that can place a circuit or module with a battery in the center. The circular folded dipole antenna placed at the rim of a circular substrate is designed to account for interference from a centrally placed circuit and battery. A matching loop is connected to both arms of the dipole, and a lumped element impedance matching circuit is added to cancel the imaginary impedance generated in the design for miniaturization. And, an LC balun is also implemented to connect it with the single-ended RF IC of the system. The simulated proposed antenna has a 10 dB impedance bandwidth of approximately 1% at 915 MHz, a reflection coefficient of -18.9 dB, and a maximum antenna gain of 1.12 dBi. The diameter of the proposed system is 0.12 λ0. To verify the operation of the proposed system, a circuit to display the incident RF power was added to measure the RF power incident to the system.

14:20 ***920 MHz Band Radio Wave Propagation Characteristics From Underground for Detecting Victims by Unmanned Aerial Vehicles***

Itsuki Mukouyasu, Makoto Kobayashi, Koichi Shin and Masahiro Nishi (Hiroshima City University, Japan)

Landslides caused by torrential rains and typhoon shave caused extensive damage. We are studying methods for detecting disaster victims by radio wave using UAV (Unmanned Aerial Vehicles) equipped with a receiving terminal. In this study, focusing on the influence of the ground surface, we evaluated the propagation characteristics of 920 MHz band through actual measurements and simulations using the FDTD (Finite Difference Time Domain) method.

14:40 ***RNN Based Proactive Received Power Prediction Using Latest and Estimated Received Power***

Motoharu Sasaki and Naoki Shibuya (NTT, Japan); Kenichi Kawamura (NTT Corporation, Japan); Nobuaki Kuno, Minoru Inomata, Wataru Yamada and Takatsune Moriyama (NTT, Japan)

We report a method for proactively predicting received power using GRU (Gated Recurrent Unit), which is one of RNN (Recurrent Neural Network) as deep learning. One of the input data of the GRU is the latest received power obtained at the receiver, and another is the pre-estimated received power estimated at the future target position of the receiver. The training and validation data use received power of Wi-Fi measured in an indoor environment. According to the prediction method using the proposed model, the root mean squared error for the validation data is about 1.0 dB for the median received power. The prediction accuracy was improved by 1.7 dB compared with the baseline which uses the latest observed values.

15:00 ***RF Energy Harvesting System for Polarization Independence and Stability of Time-Varying Signal***

Sol Kim (Korea Advanced Institute Science and Technology, Korea (South)); Ji-Hoon Lee (Korea Advanced Institute Science and Technology(KAIST), Korea (South)); Seong-Jin Kim, Hyunyoung Cho,

Hyo-Won Lee and Jong-Won Yu (KAIST, Korea (South))

This paper presents an RF energy harvesting system for polarization independence and stability of the time-varying signal. The harvesting system has an antenna, a rectifier, and a power management unit (PMU). A multi-port antenna is designed for ambient RF energy harvesting. Rectifiers are connected to the multi-port antenna to be polarization-independent. The PMU is connected to the output of the rectifier for stable operation, eliminating discontinuities in energy harvesting. In this paper, a harvesting system is designed by the proposed scheme. The stability and polarization independence of the proposed Ambient RF energy harvesting system is verified by experiments.

15:20 ***Feasibility Analysis of Ambient RF Energy Harvesting for Low-Power IoT Devices***

Ji-Hoon Lee (Korea Advanced Institute Science and Technology(KAIST), Korea (South)); Seong-Jin Kim (KAIST, Korea (South)); Sol Kim (Korea Advanced Institute Science and Technology, Korea (South)); Ju-Ik Oh, Chanhee Lee and Jong-Won Yu (KAIST, Korea (South))

This paper presents a feasibility analysis of ambient RF energy harvester for low-power IoT Devices. The RF harvester consists of a half-triangular monopole antenna, a rectifier with a matching network, and a power management unit (PMU) with a battery. In this paper, The required charging time for RF harvesting for each application is analyzed with considering the feasibility for commercialization. The Analyzed result is proposed in the guideline. Feasibility analysis of IoT device application based on proposed Ambient RF energy harvester is verified by experiments.

RS14: Antennas for Satellite Communications

Room: C3.5

Chair: Can Ding (University of Technology Sydney (UTS), Australia)

14:00 ***Diversity Methods for Mitigating Tropospheric Attenuation in Thailand for Future Satellite Communication***

Peeramed Chodkaveekityada and Chuwong Phongcharoenpanich (King Mongkut's Institute of Technology Ladkrabang, Thailand)

This paper aimed to propose diversity method for mitigating tropospheric attenuation in Thailand. Thailand experiences one of the strongest satellite attenuation conditions in the world. Three kinds of data-cloud calculation data, thaicom2&3 satellite beacon data, and rainfall data-indicate how severe tropospheric attenuation is at a moment, calling for some diversity methods to be applied Thailand's attenuation data to increase the efficiency of future satellite communication in Thailand, especially at high Ka band frequency and above.

14:20 ***Doppler Analysis for Flying Object With Microwave Signal From Low Earth Orbit Satellite***

Defeng Huang (University of Western Australia, Australia)

Doppler shift and Doppler spread due to a flying object are derived directly from Fresnel-Kirchhoff diffraction formula for microwave signals from low Earth orbit satellites in a passive forward scattering bi-static radar setup, which could be utilized to detect the size and the velocity of the flying object.

14:40 ***Antenna Requirements for Ionospheric Remote Sensing Using a Small Satellite***

Ferry Pascal Lanter and Adrian T. Sutinjo (Curtin University & Curtin Institute of Radio Astronomy, Australia); John Morgan (Curtin Institute of Radio Astronomy, Australia)

Ionospheric remote sensing using small satellites presents a cost effective and scalable opportunity to improve on current solutions by employing linear polarization to directly measure Faraday rotation. However, the unique antenna and low power constraints as a result of the small satellite package means that an antenna solution specific to this application is necessary. In this paper, we propose practicable antenna requirements that enable Ionospheric remote sensing using a 3U CubeSat. The requirements consist of gain, polarization, phase center, and mechanical parameters. To demonstrate the practicality of the requirements, simulation results of a preliminary antenna design are presented.

15:00 ***A Smaller-Than-Nominal-Swath Design Methodology for Ship Detection Synthetic Aperture Radars on Small Satellites***

Simone Mencarelli, Andrew C M Austin and Michael J Neve (The University of Auckland, New Zealand)

A non-conventional design approach for low-cost small satellites synthetic aperture radars (SAR) acquiring ambiguous images for ship monitoring is proposed here. The resulting system design allows using narrow antennas, for large nominal swaths, with width compatible with the largest side of a CubeSat while keeping a reasonably low transmit power by reducing the imaged swath to a fraction of the nominal one. It is shown that for an antenna of size 0.3x2.8 m and a transmit power of 100 W, adequate imaging performances for the application can be obtained over a swath of 25 km at an incidence angle of 30° for a sensor orbiting at 500 km.

15:20 ***Impact of Magnetometer Boom With Radio Wave Experiment on RIME Performance Aboard JUICE***

Ronny Hahnel (Technische Universität Dresden, Germany); Dirk Plettemeier (Dresden University of Technology, Germany); Lorenzo Bruzzone (University of Trento, Italy)

The ESA (European Space Agency) mission JUICE (JUpiter ICy moon Explorer) has the goal to explore Jupiter and three of the Galilean moons. After a flight of more than seven years JUICE will arrive the Jovian system in 2030. The objective of the Radar for Icy Moons Exploration (RIME) will be the investigation of the subsurface structure of the celestial bodies. In order to ensure the scientific objectives it is necessary to analyse interfering influences between the radar sounder and other experiments aboard JUICE. Due to its dimension and orientation the J-MAG magnetometer boom with the Radio Wave Experiment (RWI) could effect the RIME performance. Therefore, the paper investigates the impact and identifies possible solutions.

Wednesday, November 2 15:40 - 16:10 (Australia/Sydney)

Afternoon Tea

Wednesday, November 2 16:10 - 17:50 (Australia/Sydney)

CS8: mm-wave and THz-wave antennas

Room: C3.3

Chairs: Hiroyuki Arai (Yokohama National University, Japan), Yoshiki Sugimoto (Nagoya Institute of Technology, Japan)

16:10 ***Wideband Design of 2×2-Element Dielectric-Filled Waveguide Slot Subarray for 350-GHz Band***

Takashi Tomura and Shohei Ogura (Tokyo Institute of Technology, Japan); Lin Lin (Panasonic Industry Co., Ltd, Japan)

This paper presents a wideband design of a 2×2-element dielectric-filled waveguide slot subarray for 350-GHz band. The subarray is fed by a corporate feed circuit and composed of a cavity and slots. The subarray is analyzed by hybrid method of moments and finite element method and optimized by genetic algorithm. The optimized subarray shows 22% reflection bandwidth where reflection is below -14dB. The solid walls of the designed antenna are going to be replaced with post walls.

16:30 ***Focal Region Ray Tracing of Dielectric Lens Antennas for Multibeam Designing***

Muhsin Muhsin and Kamilia Kamardin (Universiti Teknologi Malaysia, Malaysia); Yoshihide Yamada (Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, USA)

Multibeam lens antennas are promising technology for future wireless communications. The most well-known multibeam lens is the Abbe's sine condition lens. On multibeam applications, finding optimum feed position is required. Focal region ray tracing is a very useful technique to find possible best feed position. In this paper, focal region ray tracing on Abbe's sine condition lens is presented. Lens shape is determined by the lens shaping method. Then, the ray tracing is conducted. It shows good agreement with the theoretical locus of Abbe's sine condition lens. Electromagnetic simulation at 28 GHz also shows good multibeam radiation pattern in wide angle range.

16:50 ***Wide-Angle Scanning and Gain Enhancement of Array Antenna by Dielectric Lens***

Satoshi Sugaya (Yokahama National University, Japan); Hiroyuki Arai (Yokohama National University, Japan)

In this paper, we propose the dielectric lens that enables the scanning range expansion and gain enhancement of

array antenna. We apply the proposed lens to an 8-element array antenna with a gain of 14.7 dBi and a scanning range of ±41°. As a result, the scanning range is extended to ±62° and the realized gain is greater than 21 dBi at all scanning angles.

17:10 ***Low Profile Cylindrical Lens Antenna With Matching Layers for 2-Dimensional Beam-Scanning***

Yoshiki Sugimoto (Nagoya Institute of Technology, Japan); Tuan Hung Nguyen and Nguyen Quoc Dinh (Le Quy Don Technical University, Vietnam); Shuya Suzuki, Takanori Narita, Kunio Sakakibara and Nobuyoshi Kikuma (Nagoya Institute of Technology, Japan)

This paper presents a low-profile cylindrical lens antenna with matching layers for 2-dimensional hybrid beam scanning mechanically and electrically. The proposed lens antenna is designed by applying a high dielectric constant material and a short focal length lens to reduce the entire height of the antenna. The applied matching layers are composed of periodic quadrilateral prism for easy molding manufacturing. The matching layers improve the peak gain up to 2 dB in 250-290 GHz band. The proposed antenna is a potential candidate for beam scanning applications in 300 GHz band.

17:30 ***Open Resonator Antenna Filled With Metamaterials***

Yuanlong Li and Kwai-Man Luk (City University of Hong Kong, Hong Kong)

In this paper, a planar open resonator antenna is filled with phase-gradient metamaterials to excite higher-order Laguerre-Gaussian modes and widen the operating bandwidth. The design method is briefly introduced. Benefiting from high-accuracy 3-D printing, a prototype can be fabricated to work around 100 GHz with a relatively low cost. Experiments show the proposed antenna can realize a peak gain of 16.8 dBi and a wide bandwidth of 13%.

CS9-III: Latest Technologies for advanced antenna and measurement systems (Part III)

Room: C3.6

Chairs: Takashi Hikage (Hokkaido University, Japan), Yuanfeng She (National Institute of Advanced Industrial Science and Technology, Japan)

16:10 ***Near-Field Measurement and Far-Field Characterization of Antennas in Microwave, Millimeter-Wave and THz Wave Band Based on Photonics***

Shintaro Hisatake (Gifu University, Japan)

We show antenna far-field characterization using photonics-based near-field visualization system. The photonics technology enables near-field visualization in the range from 1 GHz to at least 600 GHz with the same system configuration. As an example, antenna characterization at 300 GHz band based on planar and cylindrical scanning will be discussed.

16:30 ***Experimental Study of Efficiency With Inductance Load and Relay Coil for Magnetic Field Coupling WPT***

Tamami Maruyama (National Institute of Technology, Hakodate College, Japan); Koki Shibata (National Institute of Technology Hakodate College, Japan); Masashi Nakatsugawa (National Institute of Technology, Hakodate College, Japan)

In magnetic field coupling wireless power transmission, the effects of inserting a parasitic coil between the transmitter and receiver coils and inductance loading on the wireless power transmission efficiency were investigated through measurements using a vector network analyzer. We achieved the significant improvement in wireless power transmission efficiency from 8 % to 44 % at the design frequency of 2 MHz by inserting the parasitic coil for relay between transmission coil and received coil on all of which were impedance loaded, while the improvement in efficiency was only a few per cent when either inductances were loaded or only relay coils were inserted. The measured and analyzed results of both efficiency and maximum efficiency were very similar variation for frequency, although the levels of efficiency of experimental results are less than analyzed one.

16:50 ***W-Band Millimeter-Wave Antenna Measurement System Using an Optical Fiber Link Millimeter-Wave Generator***

Satoru Kurokawa (National Institute of Advanced Industrial Science and Technology, Japan); Michitaka

Ameya (NMIJ/AIST, Japan); Masanobu Hirose (7G aa Co., Ltd., Japan)
We have newly developed a W-band millimeter-wave signal generator using an optical second-order harmonic generation technique for a LiNbO3 Mach-Zehnder optical intensity modulator. For generating the millimeter-wave from 75 GHz to 110 GHz, our developed signal generation technique uses the signal generator from 18.75 GHz to 27.5 GHz, a microwave amplifier, the LiNbO3 Mach-Zehnder optical intensity modulator, and a photodiode. The system can generate the millimeter-wave signal level of more than -30 dBm. We demonstrated antenna radiation pattern measurement for a standard gain horn antenna and an open-ended waveguide probe.

17:10 ***Near-Field Measurement for 5G Modulated-Signal Radiated From the Antenna***
Soon-Soo Oh and Dong-Woo Kim (Chosun University, Korea (South)); Jong-Hyuk Lim (National Radio Research Agency (RRA), Korea (South)); Kangwook Kim (GIST, Korea (South)); Young-Bae Jung (Hanbat National University, Korea (South))
In this paper, the measurement technique of the relative phase of 5G NR digitally-modulated signal has been proposed. The detected signal by using the VNA converted into the two-channel receiver was utilized. The probability distribution function technique of the cumulative distribution function and medium value (50 % CDF) were utilized. The relative phase of the signal agreed with that of the CW signal. The relative phase retrieved by the proposed technique in this paper can be used for the near-to-far field transformation.

17:30 ***Measurement of a Cryogenically Cooled Ultra Wideband Feed Horn for the Effelsberg Telescope***
Alex Dunning, Ken Smart, Nick Carter, Michael Bourne, Paul Doherty and Santiago Castillo (CSIRO Space and Astronomy, Australia)
We present the radiation patterns and S-parameters of a UWB feed designed for the Effelsberg 100m radio telescope, measured at a cryogenic temperature of 50K. Compensation is made for thermal changes which have an impact on dielectric properties as well as the dimensional stability of mechanical parts. There is excellent agreement between the measured and simulated results.

OS4: Beamforming

Online Room A

Chair: Lu-Yang Ji (Northwestern Polytechnical University, China)

16:10 ***Circularly Polarized Wide-Angle Beam Scanning Circular Array Antenna***
Lu-Yang Ji, Meng-Jie Li and Rui Yang (Northwestern Polytechnical University, China); Guo-Dong Han (The 54th Research Institute of China Electronics Technology Group Corporation, China)
In this paper, a left-handed circularly polarized wide-beamwidth array element is proposed with an overlapped impedance and 3-dB axial ratio bandwidth from 1.9GHz to 2.2GHz. It consists of a circular microstrip patch with rectangular notched structures as the main radiator, a circular parasitic patch and a metal ring to broaden the impedance and 3-dB axial ratio bandwidth, and four metal posts to improve the beamwidth. A 12-element circular array is formed by using the aforementioned element, which can realize a wide beam scanning range from -72° to +72° in the elevation plane.

16:30 ***Phased Array of Dielectric Cuboid Antenna at 300 GHz Band***
Towa Ohno, Ryusei Sakai and Shintaro Hisatake (Gifu University, Japan)
We show the basic characteristics of a phased array of dielectric cuboid antenna operating at 300 GHz band based on a simulation. The antenna gain, radiation pattern, and beam steering characteristics are examined. In the 4-element linear array configuration with a 1.0 mm × 5.5 mm aperture size, the maximum antenna gain of 20.3 dBi was achieved though it decreases at the wider steering angle. The beam steering range of ±17.6° was achieved.

16:50 ***Null-Steering Metaspiral Antenna***
Tomoki Abe, Junji Yamauchi and Hisamatsu Nakano (Hosei University, Japan)
Null-steering is demonstrated using a metaspiral antenna, which has two feed points and an extremely low-profile structure on the order of 1/100 wavelength. The metaspiral antenna radiates a left-handed circularly polarized (CP) wave at a low design frequency and a right-handed CP wave at a high design frequency. A null-field point is created within the CP radiation pattern at these two frequencies. For this, the excitation amplitude and phase at one feed point are changed, while those at the other feed point are fixed. It is found that the

intensity of the radiation field at the null-field point is less than -25 dB.

17:10 ***Synthesizing Multiple Beams, Sum and Difference Beams at 28GHz Based on A Programmable Metasurface***

Jiawei Wang (China)

Programmable metasurfaces (PMs) are consisted of reconfigurable digital elements, and electromagnetic properties of the PMs can be manipulated by configuring digital states of these elements. This paper proposesto synthesize multiple beams, sum and difference beams based on a PM. Theoretical calculations validate the functions of the presented PM.

17:30 ***Inverse Design of Antenna Beam Pattern for Millimeter-Wave Base Station Applications***

Jeon hong Park (Sungkyunkwan University, Korea (South)); Celso Leite (Samsung Electronics, Korea (South)); Keum Cheol Hwang (Sungkyunkwan University, Korea (South))

Beam pattern design for beamforming is an essential requirement for base station operation in the 5G NR millimeter wave band. A beam pattern design requires tuning the phase shifter value of the antenna, and it takes expensive computational cost to find the desired beam pattern. In this paper, we propose a method to obtain the phase shifter value corresponding to the desired beam pattern through a DNN (Deep neural network) based model to reduce the iterative computational cost. The DNN model is trained based on the extracted data through the simulation tool, and the validation is performed by comparing a simulated beam pattern using estimated phase shifter values through trained DNN model with desired beam pattern.

OS5: Radars

Online Room B

Chair: Neng-Wu Liu (Xidian University, China)

16:10 ***Radar Working Mode Recognition Algorithm Based on Siamese Network and Deep Auto Encoder-Affinity Propagation***

Jingpeng Gao, Tingfei Wang and Fang Ye (Harbin Engineering University, China)

To solve the problem that the traditional Support Vector Machine-based method can only recognize known modes and has low accuracy, a radar working mode recognition algorithm was proposed. According to the theory of convolution and bidirectional gated recurrent units, the algorithm designs the Siamese Network to extract signal characteristics, recognize known working modes and distinguish unknown modes. Then, the unknown working modes is recognized by the connection of the Deep Auto Encoder and Affinity Propagation clustering algorithm. Simulation results show that the algorithm, superior to the traditional one in recognition rate with known mode 93.6% and unknown 87.3% under 5% measuring error, can effectively improve radar working mode recognition.

16:30 ***Breathing Detection via a UWB Radar***

Marcelo B Perotoni (UFABC, Brazil); Daniel de Souza and Claudio J. Bordin, Jr. (Universidade Federal do ABC, Brazil); Gustavo Vieira and Fernando Castilho (FlexMedia, Brazil)

This paper reports the acquisition of breathing signals using a commercial Ultra-wide band radar (5 to 11 GHz). In an indoor environment, the radar captures echoes from an adult breathing at a distance of approximately 1 meter. Singular Value Decomposition and Empirical Mode Decomposition enable the recovery of the low-frequency breathing signals in the time domain.

16:50 ***Bistatic HFSWR Impulsive Interference Suppression Based on Data Fusion***

Na Cui (Harbin Institute of Technology, China); Changjun Yu (Harbin Institute of Technology(Weihai), China)

In this paper, a new method for suppressing impulsive interference of bistatic radar is proposed. The initial interference suppression is performed first, and then the information of each receiving station is fused based on the signal-to-noise ratio criterion. Its performance is verified via simulations.

17:10 ***Preliminary Study on Receiving Status at MLAT Station and Estimated Aircraft Position***

Junichi Honda (Electronic Navigation Research Institute, Japan); Yasuyuki Kakubari (Electronic

Navigation Research Institute, MPAT, Japan); Takuya Otsuyama and Keisuke Matsunaga (Electronic Navigation Research Institute, Japan)

This paper is concerned with an analysis of the receiving status of 1090 MHz Mode S signals observed at multilateration (MLAT) receiver stations. The MLAT system uses the Time Difference of Arrival (TDOA) technique to estimate aircraft positions. Consequently, the receiving status of each receiver station differs corresponding to the allocation of receivers and actual aircraft positions. In this paper, we show the amounts of signals detected at MLAT receiver stations. Furthermore, it demonstrates that the receiving status and the estimated position accuracy depend on the propagation path between the receiver and the aircraft.

17:30 ***Parameter Estimation of LFM-BPSK Composite Modulated Radar Signal Based on Multi-Output Regression Network***

Pengjie Zhao, Jingpeng Gao and Tingfei Wang (Harbin Engineering University, China)

Aiming at the problem of high relative error in parameter estimation of LFM-BPSK radar signal by traditional decomposition algorithm, this paper proposes a parameter estimation algorithm for LFM-BPSK based on Multi-Output Regression Network (MORN). The algorithm first innovatively designs the 1D-CNN-BiGRU network pre-training for feature extraction, then weights migration to the MORN network. The simulation results show that the relative errors of symbol rate, modulation frequency slope and carrier frequency are as low as 9.73 %, 10.80 % and 6.65 % at -6dB SNR respectively. The algorithm has good engineering value and can be extended to more composite modulated radar signals.

RS15: Reflectarrays

Room: C3.4

Chairs: Jian Yang (Chalmers University of Technology, Sweden), Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain))

16:10 ***Ultra-Wideband Dielectric Reflectarray Antenna With OAM Beams for mm-Wave Applications***

Ali Ali (Institute for Communication Systems, United Kingdom (Great Britain) & University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))

The proposed structure is presented to improve the inherited limited bandwidth and reduce the production of grating lobes in reflectarray antennas (RAs). A dielectric RA with 200 mm × 200 mm is designed and simulated to produce an orbital angular momentum beam (OAM) of the second mode with averaged realized gain of around 20 dBi in the band of 25-40 GHz, which covers most of 5G mm-wave bands (n257, n258, n260, and n261). To achieve the mentioned specifications, an inter-element spacing of 0.25λ is adopted.

16:30 ***Impact of Addressing Techniques on Liquid Crystal-Based mm-Wave Reflectarrays***

Robert Guirado and Gerardo Perez-Palomino (Universidad Politécnica de Madrid, Spain); Eduardo Carrasco (Universidad Politecnica de Madrid, Spain)

In this paper, different addressing techniques for driving 2D reflectarrays based on Liquid Crystal are analyzed, considering the practical advantages and disadvantages of each of them. Their specific performance implications in mm-wave devices, as well as the main challenges and differences with respect to optical devices, are discussed and analyzed for the first time, and practical implementation guidelines are reported.

16:50 ***Development of Scanning Spot Beam Reflectarray Antenna***

Yusuke Kaimori, Shigeru Makino and Masayoshi Takao (Kanazawa Institute of Technology, Japan); Shin-ichi Yamamoto and Yasuhiro Nishioka (Mitsubishi Electric Corporation, Japan)

Conventional multispot beams and multiscanning beams have been developed using a single reflector by combining the characteristics of reflectarray antennas, which change the beam direction, depending on the frequency and polarization. In this study, we developed a design method and obtained measurement results of a scanning spot beam reflectarray antenna whose beam direction is changed by the frequency in the elevation direction and polarization in the azimuth direction.

17:10 ***Single Layer Unit Cell With Reduced Phase Sensitivity for X-Band Reflectarray Applications***

Panagiotis Ioannis Theoharis and Raad Raad (University of Wollongong, Australia); Faisel EM Tubbal

(University of Wollongong, Australia & The Libyan Center for Remote Sensing and Space Science, Libya)
In this paper a single layer multi-resonant unit cell with a reduced phase sensitivity for X-band wideband reflectarrays is presented. The unit cell employs a Jerusalem cross and four pairs of concentric square loops and is arranged in a rectangular grid. The proposed unit cell achieves a reflection phase response of 426° and a reduced reflected phase sensitivity. This results in low quantization phase errors of ±6.17°and element bandwidth of 13% at 12GHz by considering a 45°margin error. Finally, the proposed unit cell presents linear and parallel phase curves ranging from 10 to 14GHz, showcasing its potential for wideband reflectarrays applications operating in X-band.

17:30 ***Single-Layered Reflectarray Antenna With Branch Elements***
Masayoshi Takao, Shigeru Makino and Yusuke Kaimori (Kanazawa Institute of Technology, Japan); Shin-ichi Yamamoto and Yasuhiro Nishioka (Mitsubishi Electric Corporation, Japan)
A reflectarray antenna (hereinafter referred to as "reflectarray") applies the reflection phase control function of frequency selective reflector to a plane reflector. Various beam shapes can be formed by appropriately selecting the mirror surface configuration and shape of the resonance elements. In this study, the shape of the resonant elements of the reflectarray, which changes the beam direction depending on the polarization, is investigated.

RS16: Sensors

Room: C3.5

Chairs: Kamal Gupta (Defence Science and Technology Organisation, Australia), Ick-Jae Yoon (Chungnam National University, Korea (South))

16:10 ***A GSM Band RF Sensor Antenna***
Sourabh Santosh (Indian Institute of Technology(ISM) Dhanbad, India); Sushrut Das (IIT(ISM) Dhanbad, India)
An RF sensor antenna for GSM 800 and GSM 1800 band is presented in this work for measuring the ambient radiations from nearby base stations or mobile handsets. A dual resonance is obtained by cutting an E-type slot on a spatula-shaped patch. Measured peak gain varies from 0.6-1.65 dBi in lower band and 2-3.2 dBi in upper band. The antenna factor over the frequency band varies from 26 to 33.2 dB/m.

16:30 ***Complementary C-Shaped High-Sensitivity Resonator Sensor for Material Characterizations***
Pongphan Leelatien (Thammasat University, Thailand)
This paper presented a high-sensitivity sensor for microwave characterization of the dielectric materials. The novel design of the proposed sensor is based on a Complementary C-Shaped Resonator (CCSR) topology. The CCSR is printed in the ground plane and coupled with the microstrip transmission line. The sensor operates in the frequency band between 1.43 GHz to 2.24 GHz with the resonance frequency at 2.24 GHz with a notch depth of -19.43 dB. The sensitivity analysis of the sensor due to variations in the relative permittivity and loss tangent of the material under test (MUT) was performed via series of numerical simulations. The numerical studies show the high sensitivity of the sensor corresponding the variations of material dielectric properties.

16:50 ***An Improved RHCP Archimedean Spiral Antenna for Glacial Environmental Sensor Networks***
Muhammad Abdur Rehman Hashmi and Paul Brennan (University College London, United Kingdom (Great Britain))
An improved version of a printed RHCP Archimedean spiral antenna for glacial environmental sensor networks is presented. Two changes have been made to the previous design. Firstly, the microstrip connections between the balun and the antenna arms have been tapered. Secondly, the antenna arms have been rounded at the edges towards the antenna boundary. These measures have improved the antenna performance in the following ways. Firstly, the signal quality has been improved by minimizing reflections and signal distortion. Secondly, the microstrip tapering between the balun and the antenna arms has increased the radiating surface area in the region. Resultantly, significant improvements in the antenna's reflection coefficient, gain, total efficiency, and axial ratio have been observed.

17:10 ***A Design of Broadband Axial Ratio Ellipse Microstrip Antenna for CP-SAR Sensor***
Yohandri Yohandri, Fauzan Alhaqqi and Khairi Budayawan (Universitas Negeri Padang, Indonesia)
A design of broadband axial ratio ellipse microstrip antenna with slotted parasitic is presented in this paper. The

antenna structure is made up of two layers of low dielectric constant substrate, an ellipse radiating shape, and an ellipse slotted parasitic patch. Circular polarization radiation is generated by rotating the ellipse 45 degrees relative to the y axis. In this proposed antenna, a single proximity feed has been adopted. The finite element method (FEM) was operated to optimize the design and achieve good circular polarization at the center frequency of 5.3 GHz. The proposed antenna dimension was optimized with a relative dielectric constant of 2.17, a loss tangent of 0.0005, and a substrate thickness of 1.6 mm. The simulated impedance bandwidth and axial ratio bandwidth are 610 MHz and 475 MHz, respectively. Based on the simulated results, the design of proposed antenna can be implemented for the CP-SAR sensor.

17:30 ***Flexible Low-Profile On-Metal Tag Antenna for Asset Tracking and Identification***

Nurfarahin Miswadi (Universiti Teknologi Mara, Malaysia); Nurul Huda Abd Rahman and Suhaila Subahir (Universiti Teknologi MARA, Malaysia); Eng Hock Lim (Faculty of Engineering and Science, UTAR, Malaysia); Mohd Aziz Aris (Universiti Teknologi MARA Terengganu, Malaysia); Chan Kean Mun Action (Sevin Technology Sdn Bhd, Malaysia)

A flexible tag antenna with a compact size of 59mm x 10mm x 3.2mm is designed for an on-metal application. However, a compact size tag will suffer radiation pattern distortion and a shorter read range. Therefore, a folded stacked radiation patch with stub has been employed to reduce the size while maintaining a good read range and wider beamwidth. The proposed tag antenna operates at 911MHz with a good read range of 20m with 154.7 degrees (E-plane) and 102.6 (H-plane) beamwidth for on-metal application.

Wednesday, November 2 18:30 - 21:30 (Australia/Sydney)

Banquet and Award Ceremony

Location: No. 1 King Street, Darling Harbour. Boat name: The MV Jackson superyacht

Thursday, November 3

Thursday, November 3 8:30 - 10:10 (Australia/Sydney)

CS10: Recent Developments for Multifunctional and Innovative Antenna Technologies

Room: C3.3

Chairs: Shu-Lin Chen (University of Technology, Sydney, Australia), Yanhui Liu (University of Electronic Science and Technology of China, China)

8:30 ***A Ku-Band Circular-Polarized Horn Antenna Based on a 3D Printed Polarizer***

Yunhao Fu, King Yuk Chan and Sheng Huang (The University of New South Wales, Australia); Rodica Ramer (University of New South Wales, Australia)

In this paper, a compact circular-polarized horn antenna is presented, based on a proposed 3D printed polarizer. The antenna consists of a transition between rectangular and circular waveguides, a septum polarizer for liner-to-circular polarization conversion, and a conical horn for radiation. By employing the 3D printing technique, the configuration printed with resin material will behave as the supporting structure, where the outer walls could be copper plated as boundaries; more importantly, the electric property of cured resin is also utilized to form a septum for phase delaying, finally realizing circular polarization (CP). At the feeding port of the designed horn, the simulation shows a superior reflection of -20 dB, covering the entire Ku band from 12 to 18 GHz. Accordingly, the axial ratio (AR) of CP is within 1.4 dB crossing the operational bandwidth, with realized gains between 9.8 and 12.9 dBi. The proposed work has the advantages of an integrated and compact configuration, light weight, and high fabrication accuracy but with low fabrication cost.

8:50 *Circularly Polarized Slotted Waveguide Leaky Wave Antenna at W Band for Radar Application*

Shilpi Singh and Ananjan Basu (Indian Institute of Technology Delhi India, India)

This article presents a circularly polarized leaky wave antenna at W band for radar and imaging applications. For achieving circular polarization, a dielectric layer with array of patches is introduced above rectangular slotted waveguide antenna. The proposed prototype antenna shows simulated gain around 17 dB and axial ratio below 3 dB over the frequency band of operation. Both left hand polarized and right hand polarized beam shows 7° continuous beam scanning from broadside to endfire direction.

9:10 *Multi-Antenna-In-Package With High Isolation*

Ya-Xing Wang (Shenzhen University, China); Shi-Zhong Liu (China Ship Development and Design Center, China); Bin He (Technology Center XLAB RF Lab Huaqin Technology Co. Ltd., China); Zhe Chen and Tao Yuan (Shenzhen University, China); Xianqin Hu (Avaryholding, China)

A millimeter-wave antenna system with a compact structure and high isolation is investigated in this paper. Three patch antennas are integrated into a limited space (1.2·λ0 × 1.2·λ0). The fundamental TM01 mode of the patch antenna is excited by a probe. The common bandwidth of these patches is from 23.5 to 24.4 GHz (3.76%). In the operation band, high isolation can be guaranteed by rotating the patches by 45°and introducing an X-shaped decoupling structure. With these features, the system is suitable for integration with chips and it can be applied to Antenna-in-Package (AiP). Therefore, it has promising applications in radar sensing, ranging, and positioning.

9:30 *A Frequency Reconfigurable Metasurface Based on Liquid Metal*

Lu-Yang Ji, Rui Yang, Meng-Jie Li, Lin-Xi Zhang and Jian-ying Li (Northwestern Polytechnical University, China)

This paper proposes a frequency reconfigurable metasurface, which based on liquid metal and can continuously change its operating frequency from 2.9 GHz to 7.3 GHz. The unit cell is a two-layer structure. Arrow-shaped liquid metal microchannels and a solid metal ground plane are etched on each side of the bottom layer. By changing the length of the arrow arms, the resonance frequency can be changed. The top layer is used for sealing with 5 through-holes to the bottom layer for injection and withdrawal the liquid metal. A 5 × 5 metasurface with the aforementioned unit cells has been fabricated to verify the frequency reconfiguration performances.

9:50 *A Low-Profile Polarization Reconfigurable Antenna*

Pan Guo (University of Electronic Science and Technology of China, China); Shu-Lin Chen (University of Technology, Sydney, Australia); Yanhui Liu (University of Electronic Science and Technology of China, China)

In this paper, a novel multi-polarization reconfigurable antenna using an artificial magnetic conductor (AMC) reflector is proposed. The antenna consists of seven pairs of dipoles distributed on both the top and bottom surface uniformly. By turning ON or OFF PIN diodes connected with different dipoles, seven linear polarizations (LPs) at a 25.7 deg interval in azimuth plane can be obtained. The designed AMC unit pattern is a circular ring surrounded by seven sectors, which is helpful to balance the bandwidth and gains for seven LPs. By designing a plane with circular AMC array and employing it as a reflector to enhance the directivity, the reported antenna has a wide impedance bandwidth between 4.21 and 5.32 GHz (23.1%). The overall profile is 0.133λ L at 4.2 GHz.

CS11: Advanced Antenna Arrays and Multibeam Scanning Systems

Room: C3.6

Chairs: Maral Ansari (University of Technology Sydney, Australia), Wei Lin (University of Technology Sydney, Australia)

8:30 *Wideband Hybrid Couplers and Their Applications to Multi-Beam Antenna Feed Networks*

He Zhu (University of Technology Sydney, Australia); Lizhao Song (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia); Y. Jay Guo (University of Technology Sydney, Australia)

This paper presents a dual-layer 180° hybrid coupler design with a wide operating bandwidth. The design can achieve a high isolation level between the sum and difference ports across a 30% bandwidth. The power division can be made equal or unequal between two ports by controlling the impedance of the shunted stubs and connected transmission lines. Based on the proposed hybrid couplers, the configurations of two multi-beam antenna feed networks, which can produce 6 and 12 beams, are synthesized. It is demonstrated that such multi-

beam antenna feed networks can be built using only180º hybrid couplers and phase shifters, and the proposed coupler design is an excellent candidate for building such networks with a wide bandwidth.

8:50 ***Validation of Phased Array Mutual Coupling Simulation With Analytical Calculation***

Bahare Mohamadzade (CSIRO Astronomy and Space Science, Iran); Douglas B Hayman and Alex Dunning (CSIRO, Australia); Stephanie Smith (CSIRO & Astronomy and Space Science, Australia); Mark Bowen (CSIRO, Australia)

We validate our use of CST Microwave Studio for the analysis of a large, phased array by evaluating array parameters of a simple two-dipole array with an analytical model and CST. An analytical approximation of the mutual coupling and element impedance is compared with the results from the simulation software. The agreement between analytical and modelled results gives us confidence we are using the modelling software correctly and interpreting the results correctly. Using the impedance or scattering matrix for the array in this way will allow us to perform an analysis with LNAs using network theory separately from the full wave electromagnetic simulation software.

9:10 ***Ka-Band Huygens Array With High Realized Aperture Efficiency for 5G Wireless Applications***

Wei Lin (University of Technology Sydney, Australia); Richard W Ziolkowski (University of Arizona, USA & University of Technology Sydney, USA)

9:30 ***Yagi-Uda Monopoles With Elevated-Angle Suppression for Endfire Radiation***

Wen Yubo (UTS, Australia); Peiyuan Qin (University of Technology Sydney, Australia)

For monopole antenna mounted on a finite ground plane, the direction of its peak-radiation has an angle elevated off the horizontal plane. From the analysis based on spherical vector wavefunctions (SVWF), it is shown that the elevated angle arises from higher order transverse magnetic (TM) modes, which are mainly excited by the ground plane. By inserting resonance structures, i.e., slots, in the ground plane, a dipole-like (TM 01 mode dominated) radiation pattern can be achieved with a maximum radiation along the ground plane. Accordingly, a new monopole-based Yagi-Uda antenna is proposed with the main beam along the ground plane. It has an improved gain compared with the traditional one without inserting resonant structures on the ground. A sector of a circular Yagi-Uda array operates at 3 GHz is then simulated and measured for the verification of the method.

9:50 ***Design of a Waveguide Two-Plane Coupler With a Different Division Ratio in Horizontal and Vertical Directions***

Qi Li, Jiro Hirokawa and Takashi Tomura (Tokyo Institute of Technology, Japan)

This manuscript releases a novel two-plane coupler with a different division ratio in the horizontal and vertical directions working from 27.65GHz to 28.85GHz, with 4.1% fractional bandwidth. Compared with a previous two-plane coupler, this new division distribution is based on advanced and comprehensive cognition of the mechanism for the waveguide modes inside the coupled region. By tuning the phase difference brought by TE20-like mode and TM11-like mode in the quarter section, the final output can realize the designated division ratio in the horizontal and vertical directions.

RS17: Polarization Related Techniques

Room: C3.4

Chairs: Su Yee Aye (National University of Singapore, Singapore), Ala Sharaiha (Université de Rennes 1 & IETR, France)

8:30 ***Monopole Antenna With Dual-Band and Dual-Sense of Reconfigurable Circular Polarization***

Ankit Bhattacharjee (Indian Institute of Technology, Dhanbad, India); Santanu Dwari (Indian Institute of Technology (ISM) Dhanbad, India)

A simple design of a dual sense circularly polarized antenna for dual band application is proposed here. The design consists of a microstrip line fed rhombus shaped ring monopole which generates multi-band response, a modified ground plane which helps for the wideband impedance matching and generating circular polarization (CP) in dual-band, PIN diodes as switching elements and biasing circuit for controlling the diodes. Dual sense of polarization in two different bands can be reconfigured by controlling the ON - OFF states of only two PIN diodes. To validate the simulated results, a prototype of the antenna is fabricated and measured. Measured results show that a wide overlapped bandwidth (by considering |S11| ≤ -10 dB and axial ratio ≤ 3 dB) of > 68.5% in lower band and > 8.2% in upper band are obtained from the fabricated prototype.

8:50 ***A New Design of a Fabry-Perot Cavity Antenna for Beam-Scanning With Polarization-Reconfiguration***

Young-Geun Jeon and Gwang-Ro Yun (University of Sejong, Korea (South)); Dongho Kim (Sejong University, Korea (South))

9:10 ***C-Band Dual-Polarized Hat-Fed Reflector Antenna***

Su Yee Aye (National University of Singapore, Singapore); Tse Tong Chia (Temasek Laboratories@NUS, Singapore); Sigurd Huber (German Aerospace Center (DLR), Germany); Koen Mouthaan (National University of Singapore, Singapore)

A C-band dual linear polarized feed for a self-supported reflector antenna is presented for the frequency range of 5.2-6.2 GHz. The main parabolic reflector of the antenna has an F/D of 0.37. The design objectives are to maximize the antenna efficiency over the 1 GHz bandwidth while maintaining a simple design of the feed. The measured radiation patterns in two principal planes, gain, and cross polarization versus frequency of the reflector antenna are presented.

9:30 ***Orthogonal Polarized Omnidirectional Antenna Composed of Halo Antenna With Parasitic Elements and Dipole Antenna***

Tomokazu Mizutani and Naobumi Michishita (National Defense Academy, Japan); Hiroshi Sato (Panasonic Corporation, Japan); Yoshio Koyanagi (Panasonic, Japan); Hisashi Morishita (National Defense Academy, Japan)

This paper proposes a small-diameter, low-profile and an omnidirectional orthogonally polarized antenna composed of a Halo antenna and a dipole antenna. As a result of the simulation, the characteristics of the proposed antenna are that the relative bandwidth is 8.8%, and the antenna height and diameter are 0.45λ0 and 0.13λ0 (λ0 the wavelength of the center operational frequency), respectively.

9:50 ***Polarisation Insensitive Transparent Metasurface With Dual Pass Band and Dual Stop Band for Wide-Incidence Angle Coverage Enhancement***

AmirMasood Bagheri, Shadi Danesh and Vikrant Singh (5GIC & 6GIC, Institute for Communication Systems (ICS), University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain))

A polarisation insensitive transparent metasurface with two pass bands and two stop bands is proposed for 5G outdoor to indoor (O2I) coverage enhancement. Genetic Algorithm (GA) has been applied in order to provide the structural geometry of the unit cell for this metasurface. The proposed periodic structure consists of a unit cell design consisting of five stacked transparent patterned layers of Indium Tin Oxide (ITO) coated on Polyethylene Terephthalate (PET) substrates. The proposed transmission metasurface can be easily mounted on conventional glass windows to assist the O2I 4G/5G signals for the n7 and n78 of the 5G new radio (5G-NR), as well as shielding the 2.4/5 GHz WiFi signals from penetrating outside the building thereby enhancing the security.

RS18: Antenna Feed Networks

Room: C3.5

Chair: Danai Torrungrueng (King Mongkut's University of Technology North Bangkok, Thailand)

8:30 ***Theoretical Design of Simultaneous Q/V Two-Port and Four-Port Feed Networks***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); John Kot (Young & Kot Engineering Research, Australia)

The theoretical designs of waveguide components needed to fabricate a simultaneous Q/V two-port or four-port feed network for a SATCOM ground station antenna are presented.

8:50 ***A Beam-Forming Antenna Integrating Magic-T Based Matrix Feed Network***

Yutaka Umeda, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

This paper proposes a new beam-forming antenna using a 4 × 4 matrix feed network based on planer magic-Ts. The proposed antenna consists of four microstrip antennas, four magic-Ts, and four quarter-wavelength microstrip lines to provide four beam patterns. The beam angles of 10°, −26°, −12°, and 26° are obtained according to the input ports. The reflection coefficients of the input ports are lower than −20 dB at 5.8 GHz. The feasibility and performances of the proposed antenna are experimentally confirmed.

9:10 ***Feeding Effects to Gain Enhancement of Microstrip Antennas With Partially Reflective Surfaces***

Mia Maria Ulfah (Department of Electrical Engineering, Chulalongkorn University, Thailand); Panuwat Lecturer Janpugdee (Chulalongkorn University, Thailand); Danai Torrungrueng (King Mongkut's University of Technology North Bangkok, Thailand)

Feeding effects to gain enhancement of a microstrip antenna based on a substrate integrated waveguide (SIW) with partially reflective surfaces (PRS) are presented in this paper. Two most common feeding techniques including aperture coupled (AC-SIW) and probe fed (PF-SIW) are employed. The PRS realized by a dielectric slab placed in front of the microstrip antenna and the ground plane forms a structure of Fabry-Perot cavity (FPC) to provide gain enhancement. Numerical results show that the AC-SIW antenna achieved a higher gain than the PF-SIW antenna. In addition, the FPC can improve the antenna gain by 3-4 dB.

9:30 ***A Multi-Beam Array Antenna Employing Simple 4 × 2 Beam-Forming Network Integrating Magic-T and Hybrid Coupler***

Maodudul Hasan, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

This paper presents a multi-beam array antenna using a simple 4 × 2 beam-forming network (BFN). The BFN consists of a magic-T, hybrid coupler, and two single-pole double-throw (SPDT) switches. Simulated results confirm the BFN concept with good impedance matching and high port isolation. When an antenna array is connected with the proposed BFN, four beam patterns can be obtained. The multi-beam radiation patterns (sum, difference, and two tilted beams at -15 deg. and +18 deg.) are experimentally verified using a 5.8-GHz prototype.

9:50 ***Short-Circuit Excitation Electrically Small Antenna Design With Reactive Loading***

Marwan Jadid (CEA & Grenoble Alps University, France); Christophe Delaveaud (CEA-LETI, France); Serge Bories (CEA, France); Anthony Bellion (CNES, France)

This paper presents an electrically small antenna design with short-circuit excitation and a lumped capacitor load. The antenna electrical size ka is 0.26 of maximum dimension λ/12, designed to match a differential 100 Ω reference impedance at 868 MHz. A geometrical parametric study is made to demonstrate the coupling change between the short-circuit excitation port and the lumped capacitor port. The simulated antenna performance shows complete matching to the reference impedance with 69% radiation efficiency including realistic lumped capacitor resistive losses.

Thursday, November 3 10:10 - 10:40 (Australia/Sydney)

Morning Tea

Thursday, November 3 10:40 - 12:20 (Australia/Sydney)

CS12: Multi-functional and Wideband Metasurface Antennas

Room: C3.3

Chairs: Alex Wong (City University of Hong Kong, Hong Kong), Shu-Lin Chen (University of Technology, Sydney, Australia)

10:40 ***Wideband RCA Using a True-Time-Delay Metasurface: An Experimental Demonstration***

Tayyab Ali Khan and Alex Wong (City University of Hong Kong, Hong Kong)

This paper reports a planarized wideband resonant cavity antenna (RCA) built using a true-time-delay metasurface (TTD-MS). The TTD-MS mimics a curved reflector to enable multimode resonance, hence widening the 3dB bandwidth of the RCA from 5% (for a flat metallic reflector) to 21.3% while the achieved peak gains are comparable, at around 17.5 dBi. Simulation and preliminary experimental measurements are in good agreement and show that the TTD-MS has similar radiation performances to an RCA with the curved reflector, achieving a gain-bandwidth product (GBP) of 12. The planarization achieved dramatically simplifies the antenna's fabrication.

11:00 ***3D Broadband FSS With Through Holes and Low Profile for UHF and SHF Applications***

Mengze Li and Jizhe Liu (University of Technology Sydney, Australia); Zhonghao Hu (Rosenberger Technologies Pty Ltd, Australia); Yang Yang (University of Technology Sydney, Australia)

Modern communication systems need low-frequency devices with high gain and wide operational bands. This paper proposes a frequency selective surface (FSS) with a wide passband and low profile, which can be additively manufactured. Each unit of the FSS consists of a centre cube and four surrounding walls with two metal layers covering the top and bottom sides. Through drills are introduced in the design to improve the return loss and the insertion loss in the operational band. The proposed FSS prototype is designed and can be fabricated in a single substrate with a multi-material additively manufacturing technology, and its performance is verified in simulation. It resonates at 3.75 GHz with a fractional bandwidth of 29.3%. Good out-of-band suppression is obtained as well

11:20 ***A Wideband Low-Profile Transmitarray Antenna Based on Metasurface***

Bingjie Xiang (City University of Hong Kong, China); Kwai-Man Luk (City University of Hong Kong, Hong Kong)

A wideband low-profile transmitarray antenna is proposed based on the I-shape resonator. The design is composed of a transmitarray and a reflective surface (RS). In the transmitarray element design, the I-shape resonator is sandwiched by two orthogonal polarization gratings to provide continuous phase compensation. While in the RS element design, the I-shape resonator is also used to convert the polarization and manipulate the reflecting phase. By properly designing the phase distributions on both apertures, the profile of the antenna is reduced to 1/5 of the focal length. The simulated results show that the proposed transmitarray antenna can achieve a peak gain of 24.8 dBi, a peak aperture efficiency of 46% and a 3-dB gain bandwidth of 37%. Moreover, the final profile of the transmitarray antenna is about 1.2λ at the center frequency.

11:40 ***A Compact Folded Transmitarray Antenna With Polarization-Dependent Metasurface***

Weixu Yang, Ke Chen, Junming Zhao and Yijun Feng (Nanjing University, China)

In this paper, we propose a compact folded transmitarray antenna (FTA) only using a single metasurface integrated with a planar feed and a metal plate. The proposed meta-atom is composed of a pair of identical RCP microstrip patch resonators, therefore can let the right-handed circularly-polarized incidence pass through while reflect the left-handed circularly-polarized incidence. The continuous transmission phase modulation is realized by rotating the upper patch resonator. An FTA prototype is designed, fabricated, and measured. The antenna profile is reduced to a quarter of the focal length. The results demonstrate a high aperture efficiency, a broad gain bandwidth, together with good polarization purity.

12:00 ***Multifunctional, Low-Profile, Compact and Wideband Inductive Grid-Array Metasurface Antennas***

Qingli Lin and Ming-Chun Tang (Chongqing University, China); Richard W Ziolkowski (University of Arizona, USA & University of Technology Sydney, USA)

OS6: New Transmission Lines/Structures

Online Room A

Chair: Jinfeng Li (Imperial College London & Bangor University, United Kingdom (Great Britain))

10:40 ***A Wideband High Gain Arched Slotted Patch Array Antenna by Substrate-Integrated Coaxial Line***

Min Wang and Yang Yu (Chongqing University of Posts and Telecommunications, China); Zhengchuan Chen (Chongqing University, China)

In this paper, a millimeter-wave wideband high gain arched slotted patch array antenna by substrate-integrated coaxial line (SICL) has been designed. Initially, antenna array is composed of a four-way power divider network and four arched patch elements, and its size is 8.41λ0 × 4.13λ0 × 0.09λ0. Four arched E-shaped slotted patches with different orientations are adopted to improve the impedance bandwidth. A feeding structure is consisted of two two-way T-junctions and a 180° delay line to feed these patches, while the element excites 45° purified linearly polarized wave. Then, three two-way T-junctions with quarter-wavelength impedance transformer as the four-way power divider provide the equal amplitude and uniform phase to each element for maximizing the gain of the array. Over the frequency range of 39.7-44.4 GHz, the return losses are less than -10 dB, and the maximum peak gain is 16.0 dBi. Finally, these simulated results show that the proposed array antenna have the characteristics of high gain and wideband

11:00 ***Numerical Simulation of New Transmitting Structure in Lateral Wells***

Sihan Li and Zixuan Li (University of Electronic Science and Technology of China, China)

An electromagnetic measurement while drilling (EM-MWD) model for lateral wells based on the electromagnetic field finite element method (FEM) is proposed in this paper. This model solves the problem of ineffectively transmitting the information in front of the drill pipe to the ground during lateral well drilling. This paper innovatively proposes a helical coil antenna in lateral wells. Compared with the traditional insulating gap structure, the helical coil antenna has a better transmission effect. Through the simulation analysis of this model, a series of transmission characteristic diagrams of lateral wells are obtained. The results show that the electromagnetic transmission model of the lateral well using the helical coil antenna has a better transmitting ability, providing a theoretical reference for solving practical engineering problems in the future.

11:20 ***A Dual-Passband Filter With Wide Stopband Based on Quarter-Mode Substrate Integrated Elliptical Waveguide***

Rui Wang, Zuxue Xia, Chao Wang, Xin Cao and Rui Cheng (Southwest University of Science and Technology, China)

In this paper, a miniaturized, dual-mode and dual-band (DMDB) filter with wide stopband based on quarter-mode substrate integrated elliptical waveguide (QMSIEW) is designed. QMSIEW is proposed by cutting along the substrate integrated elliptic waveguide (SIEW) magnetic wall. The filter realizes the first and the second passband respectively through the TMC010 and TMS210 modes of QMSIEW. The simulation results show that the frequency ratio of the designed DMDB filter is 2.49. The stopband bandwidth is extended to 2.32f0 with a rejection level better than 20dB between the two passbands, and there are 5 transmission zeros (TZs) out of passbands.

11:40 ***79 GHz Meandering Enclosed-Coplanar Variable Delay Lines in Liquid Crystals Encapsulated Within Independent and Shared Cavities***

Jinfeng Li (Imperial College London & Bangor University, United Kingdom (Great Britain))

New meandering enclosed-coplanar waveguide (MECPW) millimetre-wave variable delay lines are designed with a bent core line interfacing a shared layer of highly anisotropic liquid crystals (LC) GT7-29001. Impacting tunable dielectric's volume, phase-tuning range, cost, and insertion loss, two device designs are proposed, featuring an independent cavity, and a shared cavity, respectively. Up to 5°/dB of improvement in the figure-of-merit is foreseen at 79 GHz by using the shared-cavity design, with a further benefit of reducing the required LC filling volume by 1.6% per device. The size and cost reductions are promising for mass production targeting a phased array feed.

12:00 ***A Circularly Polarized Endfire Antenna Based on Single-Sided Spoof Surface Plasmon Polaritons***

Junjie Huang, Yu Shao and Changhong Zhang (Chongqing University of Posts and Telecommunications, China); Jie Zhang (University of Sheffield, Dept. of Electronic and Electrical Engineering, United Kingdom (Great Britain))

In this paper, a millimeter wave circularly polarized (CP) endfire antenna based on single-sided spoof surface plasmon polaritons (SSPPs) structure is presented. The antenna is composed of feeding terminal, transition section and asymmetric SSPPs structure. A flared slot similar with planar horn antenna is formed which leads to endfire radiation. The SSPPs structure on the top layer, together with the microstrip line on the bottom layer produces CP waves. Simulated results show that the proposed antenna achieves good endfire radiation performance within the impedance bandwidth from 26.4 GHz to 28.2 GHz and axial ratio bandwidth from 26.4 GHz to 28.5 GHz.

RS19: Bandwidth Enhancement Techniques and Wideband Antennas

Room: C3.4

Chair: Lizhao Song (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)

10:40 *Oval-Slot and Arc-Slits-Loaded UWB Planar Oval Monopole Antenna*

Agus D. Prasetyo (Telkom University, Indonesia); Deny Hamdani and Achmad Munir (Institut Teknologi Bandung, Indonesia)

This paper deals with the development of ultra-wideband (UWB) planar oval monopole antenna loaded by an oval-slot and arc-slits on its radiating patch. The proposed antenna designed with such configuration is aimed to support UWB applications. The oval-slot is made by mimicking and geometrically down-scaling the area of radiating patch, whilst two pairs of arc-slits are carved upon the patch. The tapered feed-line is employed to accommodate an impedance match for a wide-range frequency response. The configuration of planar oval monopole antenna is deployed on an RT/duroid 5880 dielectric substrate, while its characteristic response is observed at the frequency range of 1-20 GHz. The characterization result shows that the proposed antenna configuration works at the operating frequency from 1.38 GHz to more than 20 GHz, or in other terms, the geometric fractional bandwidth of more than 354.43% with two rejection bands at the frequency range of 1.95-3.47 GHz and 9.08-9.55 GHz.

11:00 *Bandwidth Enhancement by Interconnecting Double Hexagonal Loops FSS*

Nur Biha Mohamed Nafis and Mohamad Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia); Mohamed Himdi (Université de Rennes 1, France)

The paper proposed a mosaic frequency selective surface (MFSS) which comprises of the integration between Koch fractal and a basic double hexagonal loop FSS. Through this integration, the bandwidth (BW) within the first bandstop and bandpass frequency responses achieved a wideband frequency response (fractional bandwidth (FBW) > 50%), while the BW of the second bandstop frequency response improved (FBW~20%). The simulation process is conducted by using the CST software, and the FR4 substrate is used as the dielectric substrate for all of the proposed unit cells. With narrow trace width of the MFSS, the structural element can be further applied for optical transparency application with wideband filtering characteristics.

11:20 *Polarization Insensitive Reconfigurable Artificial Magnetic Conductor for Wideband Applications*

Vikrant Singh (5GIC & 6GIC, Institute for Communication Systems (ICS), University of Surrey, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); AmirMasood Bagheri (5GIC & 6GIC, Institute for Communication Systems (ICS), University of Surrey, United Kingdom (Great Britain)); Ali Araghi and Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))

This paper proposes a reconfigurable wideband artificial magnetic conductor (AMC), insensitive to the tilt-angle of linear polarization, that offers an overall AMC bandwidth of 550 MHz from 3.55 GHz to 4.1 GHz. The operating frequency of the proposed AMC can be altered by varying the reverse biasing of the varactor diodes. The proposed AMC is evaluated for variations in the tilt-angle of linear polarization and also as a reflector for a standard bowtie antenna due to its wideband characteristics. The results show its voltage-controlled wideband operation for obtaining a directional radiation pattern suitable for a typical wideband 5G base station antenna.

11:40 *Bandwidth Improvement of Single-Layer, Circularly-Polarized, Proximity-Fed Patch Antenna*

Van Linh Pham, Son Xuat Ta, Nguyen Khac Kiem and Chien Ngoc Dao (Hanoi University of Science and Technology, Vietnam); Nghia Nguyen-Trong (University of Adelaide, Australia)

This paper presents a single-layer circularly polarized (CP) proximity-fed patch antenna with bandwidth improvement. The design consists of four rectangular patches, which are fed by a common 50-Ohm microstrip line with open-ended termination through proximity coupling. By using both capacitive and inductive coupling mechanisms and carefully optimizing the positions and sizes of the rectangular patches, the antenna yields multiple resonances and minimum axial ratio (AR) points. By merging these resonances, the bandwidth is significantly enhanced. The final design yields a |S11|< -10 dB bandwidth of 16.96% (8.27 - 9.81 GHz) and AR < 3-dB bandwidth of 6% (8.89 - 9.44 GHz), the peak gain of 9.94 dBic, and radiation efficiency of >83%.

12:00 *Broadbanding of Electrically Small Hemispherical Helix Antennas*

Mina Nishie (Kanazawa Institute of Technology, Japan); Taiga Hannya (Kinden Corporation, Japan); Keisuke Noguchi (Kanazawa Institute of Technology, Japan)

Novel wireless communication systems such as IoT devices and B5G are widely spreading, high performance

electrically small antennas which is wireless interface of RF module is strongly demanded. As relationship between miniaturization of antenna and realization of high performance is trade-off, research and development for electrically small antennas are important. Though spherical helix antennas have been proposed as antennas that the size is possible to reduction by theoretical limitation, practical improvement of the antenna performance is required. This paper denotes broadbanding of the hemispherical helix antennas using an equivalent circuit with loss factor, and discuss the affects of loss factor on the wideband characteristics.

RS20: Antenna Designs

Room: C3.5

Chair: Nghia Nguyen-Trong (University of Adelaide, Australia)

10:40 *Circular Polarization of MACKEY Q-Type*

Koki Iijima, Keito Yokoe, Michinori Yoneda, Hajime Suzuki, Shigeru Makino and Kenji Itoh (Kanazawa Institute of Technology, Japan)

The metasurface-inspired antenna chip developed by KIT EOE Laboratory (MACKEY) is a small antenna that is not affected by metals. The MACKEY Q-type was developed based on MACKEY. It was miniaturized to a square of side λ/4. This study proposes an antenna that can radiate circularly polarization by cutting into the grid plate.

11:00 *Two-Dimensional Arraying of Unbalanced MACKEY*

Hajime Suzuki, Hayato Ide, Michinori Yoneda, Koki Iijima, Shigeru Makino and Kenji Itoh (Kanazawa Institute of Technology, Japan)

In this study, we examine a compact and thin metasurface-inspired antenna chip developed by the KIT EOE Laboratory (MACKEY) that can operate in free space and on metals. In particular, MACKEY II is examined when it is converted to a two-dimensional array with element spacing λ/4 and λ/2.

11:20 *Consideration of MACKEY Reverse F-Type for Multi-Band Purposes*

Kota Hakamata (7-1 Ogigaoka & Kanazawa Institute of Technology, Japan); Keito Yokoe, Kichi Wakayama, Hayato Ide, Shigeru Makino and Kenji Itoh (Kanazawa Institute of Technology, Japan)

MACKEY, which is sufficiently immune to metal objects, has been developed [1]. Here, we present an unbalanced MACKEY, which is multi-band, by using an inverted-F antenna as part of a conventional MACKEY with a dipole antenna and discuss its operating principle.

11:40 *Characteristics Study of Structure of the Antenna Composed of a Metal Box and Folded Dipole Element*

Yukiko Wada and Naobumi Michishita (National Defense Academy, Japan); Atsushi Yamamoto (Panasonic Corporation, Japan); Kazuhiro Matsumoto and Tetsuya Hishikawa (Panasonic, Japan); Hisashi Morishita (National Defense Academy, Japan)

In this study, the effect of the sides of the box on the antenna, which consists of a slotted metal box and folded dipole element, is examined. The study confirmed that the upper and lower surfaces of the metal box (xy plane) contribute to the function of the antenna, and that the removal of the left and right surfaces (yz plane) does not affect the simulation results. This result allows simplification of the antenna structure.

12:00 *A Feasibility Study of Circularly Polarized MACKEY Using Sequential Array Technique*

Michinori Yoneda, Keito Yokoe, Shigeru Makino, Kenji Itoh, Koki Iijima and Hajime Suzuki (Kanazawa Institute of Technology, Japan)

This study aimed to convert linear convectional polarization to circular polarization using an unbalanced metasurface-inspired antenna chip developed by the KIT EOE Laboratory (MACKEY). We aimed to achieve a Voltage Standing Wave Ratio (VSWR) of less than three and axial ratio of less than 3 dB in free space and on metal at 2.4-2.5 GHz. For this purpose, we proposed a circularly polarized MACKEY C4 sequential type using sequential array technology. We achieved our goal by optimizing the slit width.

RS21: Machine learning and artificial intelligence for AP

Room: C3.6

Chair: Hai-Han Sun (Nanyang Technological University, Singapore)

10:40 ***Distance Measurement Method Using Neural Network Learning of Microwave Reflection Signals***

JangHoon Jeong (Soonchunhyang University, Korea (South)); Won-young Song (ETRI, Korea (South)); Kwang-Jae Lee (Electronics and Telecommunications Research Institute, Korea (South)); Seong-Ho Son (Soonchunhyang University, Korea (South))

In this paper, we present a novel non-contact distance measurement method using microwave reflection signals and artificial neural networks. Based on data learning, this method can effectively predict the distance of an object placed in a complex environment. In particular, by using a two-step neural network, we propose a method of maintaining precision while reducing the data used for training. Through an experimental test, microwave reflection signals for each distance are acquired and the two-step neural network is trained. Finally, the distance is estimated from the microwave reflection signal measured for an arbitrary distance. Using the proposed method, we have successfully demonstrated the distance measurement of an object placed in an underwater environment.

11:00 ***Anomaly Localisation From Microwave Signals Using Deep Learning***

Wei-chung Lai (University of Queensland, Australia); Alina N Bialkowski (The University of Queensland, Australia)

Deep learning is gaining interest in the microwave imaging field due to its success across domains including medical imaging. However, deep neural networks generally require large amounts of labelled training data which is scarce in novel imaging modalities such as microwave imaging especially compared to other medical imaging modalities such as magnetic resonance imaging (MRI). Moreover, the variations of the microwave signal are weak and non-linear, which makes the task more challenging. This work demonstrates how convolutional neural networks can be applied to anomaly localisation from a relatively small amount of experimental data.

11:20 ***Basic Study of the Placement and Number of Receiving Antennas in Undersea Positioning***

Shinnosuke Sakaya and Masaharu Takahashi (Chiba University, Japan)

In this study, we investigate an undersea position estimation algorithm using electromagnetic waves as an assistive technology for divers during sea rescue. We previously proposed an algorithm to estimate the position of a transmitting antenna in the sea by using surfaces generated by machine learning. This paper investigates the placement and number of receiving antennas that give the best position estimation accuracy for our proposed algorithm.

11:40 ***Neural Network Model-Based Self-Interference Cancellers for True Full-Duplex Systems***

Qingqing Dong (The University of Auckland); Andrew C M Austin and Kevin W Sowerby (The University of Auckland, New Zealand)

12:00 ***foF2 Estimation With TEC Observation Over China Based on Random Forest Method***

Yuhang Zhang (China Research Institute of Radio Propagation, China); Weimin Zhen (China Research Institute of Radiowave Propagation, China); Liang Chen, Ming Ou, Xiao Yu and Longjiang Chen (China Research Institute of Radio Propagation, China)

The critical frequency of F2 layer (foF2) plays an important role in high-frequency communication, but the ionosonde to obtain foF2 measurements is expensive which leads to scarce stations and measurements. However, the Global Navigation Satellite System (GNSS) receiver to obtain total electron content (TEC) measurements are inexpensive and the observation sites are dense. Due to a strong correlation between the parameters of foF2 and TEC, this paper proposes a random forest (RF) method for predicting foF2 using TEC. A regional foF2 prediction model was constructed using foF2 and TEC data of 10 stations in China. Among them, 8 stations data are used for training the RF model, and the remaining 2 station data are used for model accuracy evaluation. The results show that the RMSE of RF model is 0.77MHz in mid-latitude region and 1.09MHz in low-latitude region, and the prediction accuracy is better than IRI2016 model.

Thursday, November 3 12:20 - 13:40 (Australia/Sydney)

Lunch

Thursday, November 3 13:40 - 15:20 (Australia/Sydney)

OS7: Absorbers

Online Room A

Chair: Xi Zhu (University of Technology Sydney, Australia)

13:40 ***Suppression of Multiple Reflection by Metasurface Absorber in 120-GHz-Band Close-Proximity Wireless Link***

Akihiko Hirata (Chiba Institute of Technology, Japan); Issei Watanabe (National Institute of Infomation and Communications Technology, Japan); Norihiko Sekine (National Institute for Information and Communications Technology, Japan); Akifumi Kasamatsu (National Institute of Information and Communications Technology, Japan)

We investigated a metasurface absorber integrated planar slot antenna for a 120-GHz-band close proximity wireless link. We adopted the split-ring resonators (SRRs) made by TaN on a quartz substrate for the metasurface absorber, and the measured S11 of the absorber at 125 GHz is 17 dB. We simulated the transmission characteristics of the close proximity wireless system using these absorber integrated planar slot antennas. The simulated fluctuation of S21 in the 120-130 GHz band is below 4 dB, and the delayed waves that comes from the multiple reflection between Tx and Rx antenna was suppressed.

14:00 ***Ultra-Wideband Frequency Selective Absorber With Dual Independent Notched Bands***

Lijin Zhang and Shufang Li (Beijing University of Posts and Telecommunications, China); Meijun Qu (Communication University of China, China)

A dual-layer frequency selective absorber with two adjustable notched bands is proposed to realize out-of-band RCS reduction in this paper. Two notch bands are obtained by two circular ring resonators at top of the lossless layer respectively. The structure at the top of the lossy layer loaded with lumped resistors realizes the ultrawide absorption band. By controlling the dimensions of two resonators geometrically, the two notch bands can be adjusted respectively.

14:20 ***Broadband Active Switchable Absorber With Low DC Power Consumption***

Han-jun Maeng, Gwon Gu Khang, Jeong woo Hur, Seong Ju Kim and Dongho Kim (Sejong University, Korea (South))

RS22: Antenna System Measurement and Calibration

Room: C3.3

Chair: He Zhu (University of Technology Sydney, Australia)

13:40 ***Element-Level Phase Measurement and Calibration of Array Antenna for mmWave 5G Communications***

In-June Hwang (Korea Research Institute of Standards and Science (KRISS), Korea (South)); Young-Pyo Hong and Jung-Il Park (Korea Research Institute of Standards and Science, Korea (South))

As millimeter-wave(mmWave) 5G communication is actively developed, the importance of measurement to verify its quality is emerging. In the mmWave phased array antenna, a phase deviation may occur between antennas due to manufacturing tolerances of active/passive elements, which may degrade beamforming performance. We proposed a method for measuring the element-level phase through an electro-optic(EO) probe-based measurement platform developed by KRISS. The phases of individual elements of the 28 GHz 4×1 patch antenna were measured at high speed. Antenna performance before and after calibration was compared and analyzed.

14:00 ***Field-Calibrated Electro-Optic Probe for mmWave 5G Communications***

Dong-Joon Lee and Jae-Yong Kwon (Korea Research Institute of Standards and Science, Korea (South)); In-June Hwang (Korea Research Institute of Standards and Science (KRISS), Korea (South)); Young-Pyo Hong (Korea Research Institute of Standards and Science, Korea (South))

We propose a field-calibrated electro-optic probe designed for a millimeter-wave 5G phased array antenna at the Ka-band. The fabricated probe is calibrated through a WR-28 millimeter-wave waveguide in a minimally invasive manner. Using a calibrated probe associated with heterodyning probe control system, the electric field distribution of a 4×1 phased array patch antenna at 28 GHz is presented with absolute V/m.

14:20 ***Assessing the Movement of Microwave Cables by Statistical Indicators***

Théo Richard, Jean-Hugues Le Gallou and Benjamin Etheve (CEA, France); Amélie Litman (Aix-Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, France); Nicolas Mallejac (CEA, France)

In order to reduce the uncertainties of measurement in anechoic chamber, we wish to know and quantify the impact of the movement of a cable on the reflection coefficient. When the cable is subjected to constraints on a motorized arm, the quality and movements of the cables are important to control to obtain an accurate measurement. Measurements were made on an automatic bench designed to perform a vertical displacement of a cable with different radii of curvature of the cable. A study was therefore conducted to quantify through statistical comparison indicators taking into account the measurements uncertainties if two curves are really equivalent after a movement of the cables.

14:40 ***A Wideband Unbalanced-To-Unbalanced Choke for Return Current Suppression in Antenna Measurements***

Xiaoyang Yin (The University of Adelaide, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Longfang Zou (Reco Medical LTD, United Kingdom (Great Britain)); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

15:00 ***Flux Separation Method for Gain Analysis on Telescope Antenna With Segmented Reflector***

Nozomu Kogiso (Osaka Metropolitan University, Japan); Yuki Suzuki and Seiya Matsushita (Osaka Prefecture University, Japan); Hiroaki Tanaka (National Defense Academy, Japan)

This research proposes a flux separation method for antenna gain analysis to achieve both high approximation accuracy and high computational efficiency for a radio-telescope antenna consisting of segmented reflector surfaces. To achieve high approximation accuracy, the proposed method considers the effect of diffraction occurring at the segmented reflector boundary by introducing the separation of the flux reflected around gap boundaries into their own and neighboring reflectors with adequately distributed electric field intensities. The efficiency of the proposed method is demonstrated through numerical examples for our proposed balloon-borne smart Cassegrain antenna system.

RS23: Antenna Systems for 5G, B5G and 6G

Room: C3.4

Chairs: Hosung Choo (Hongik University, Korea (South)), Noud Kanters (University of Twente, The Netherlands)

13:40 ***Reflective Metasurface for 5G mmWave Coverage Enhancement***

Anton Tishchenko (University of Surrey, United Kingdom (Great Britain)); Ali Ali (Institute for Communication Systems, United Kingdom (Great Britain) & University of Surrey, United Kingdom (Great Britain)); Christopher P. Botham (BTexact, United Kingdom (Great Britain)); Fraser Burton (BT, United Kingdom (Great Britain)); Mohsen Khalily (University of Surrey & 5G Innovation Centre, Institute for Communication Systems (ICS), United Kingdom (Great Britain)); Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))

The proposed intelligent reflective surface (IRS) is presented to compensate for the path loss and enhance the coverage of 5G networks at mm-wave band. A (π) shaped element with variable-sized dipoles, distributed in a certain way to maintain a phase length curve over 340° in the range of 23- 27 GHz, is addressed in this work. The proposed structure can be an ideal candidate for 5G mm-wave band n258.

14:00 ***Channel Estimation Errors and Their Impact on Irregular Array Performance in Massive MIMO***

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

This paper considers the impact of imperfect channel state information (CSI) on the array antenna layout design in massive multiple-input multiple-output applications. The analysis is based on channel estimation errors

resulting from the least squares estimation algorithm in pure line-of-sight channels. We show that signal to interference-plus-noise ratio gains traditionally anticipated with irregular layouts, as compared to regular ones under the assumption of perfect CSI, vanish in case of CSI imperfections for the considered scenario.

14:20 ***Link Budget Analysis of Low Earth Orbit Satellites Considering Antenna Patterns and Wave Propagation in Interference Situations***

Eunjung Kang (Hongik University, Korea (South)); YoungJu Park, JungHoon Kim and WookHyeon Shin (Agency for Defense Development, Korea (South)); Yong Bae Park (Ajou University, Korea (South)); Hosung Choo (Hongik University, Korea (South))

This paper proposes a link budget of the high-speed data communication for Low Earth Orbit (LEO) satellites in interference situations. A choke ring horn type antenna with a diameter of 77.4 mm is used as the transmitting antenna in the LEO satellite, which has a half power beam width (HPBW) of 103.2˚ and a maximum gain of 6.6 dBi at 8 GHz. The receiving antenna in the ground station is a parabolic type of antenna with a diameter of 11.3 m, and it has a HPBW of 0.2˚ with a maximum gain of 59 dBi at 8 GHz. The J/S is calculated when an unwanted interference source at altitude of 18 km and θj of 0˚ to 90˚ moves over the ground station. For J/S of 0 dB, the elevation angle θj of the unwanted power is 88.1 dBm (θj=88˚) and 75.3 dBm (θj=89˚).

14:40 ***A Miniaturized Branch Line Coupler for 5G Dual Band Applications***

Abdulkadir Bello Shallah (Universiti Teknologi Malaysia & Kebbi State University of Science and Technology, Aliero, Malaysia); Farid Zubir (Universiti Teknologi Malaysia & Faculty of Electrical Engineering, Malaysia); Mohamad Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia); Ahmad Abubakar (SAN Campus & Khalifa University, United Arab Emirates); Zubaida Yusoff (Multimedia University, Malaysia); Murtala Aminu (UTM, Nigeria)

This paper proposes a miniaturized dual-band branch-line coupler with an increased frequency ratio for 5G applications. In this design, a T-shaped line replaced the conventional line in which both the lines and stubs were folded to obtain a 46.62% size reduction compared to the standard one. Moreover, the design demonstrates an increased frequency ratio of 5 centered at 0.7 GHz and 3.5 GHz. The structure is designed on an RT/Duroid 5880 substrate and simulated using a CST-MW studio.

15:00 ***A Low Profile and Broadband Silicon-Based Dielectric Resonator Antenna***

Lei Zhou, Yin-Shan Huang, Ziqi Zhang and Liang Zhou (Shanghai Jiao Tong University, China)

RS24: Propagation Measurement

Room: C3.5

Chairs: Andrés Alayón Glazunov (University of Twente, The Netherlands & Chalmers University of Technology, Sweden), Young-Pyo Hong (Korea Research Institute of Standards and Science, Korea (South))

13:40 ***24/60-GHz Dual-Band Double-Directional Channel Measurements in Urban Cellular Access Environments***

Hibiki Tsukada, Naoya Suzuki, Riku Takahashi and Minseok Kim (Niigata University, Japan); Hirokazu Sawada (National Institute of Information and Communications Technology, Japan); Takeshi Matsumura (National Institute of Information and Communications Technology (NICT) & Kyoto University, Japan)

This paper reports the results of propagation channel measurements simultaneously performed at 24 and 60 GHz in an urban cellular access environment. A channel sounder with a phased-array antenna capable of high-speed beam steering was used to achieve double-directional full-azimuth scan measurements at the same position and at the same time at both frequencies. Statistical properties of the delay time of arrival, and the azimuth angles of departure and arrival, called large-scale parameters (LSPs), were obtained from the measured data. The results improve the accuracy of the currently widely used cluster-based millimeter-wave channel models for site-specific channel prediction.

14:00 ***An Experimental Study on DOA / DOD Measurement Method at 300 GHz Band by Double-Directional Rotating Reflector Antenna***

Toshiki Hozen and Kazuma Tomimoto (Softbank Corp., Japan); Ryo Yamaguchi (SOFTBANK Corp., Japan); Ayumu Yabuki (Softbank Corp., Japan); Masayuki Miyashita (SoftBank Corp., Japan)

Designing antennas for 300 GHz band use requires the construction of a propagation model. To achieve this, it is

important to grasp the DOA (Direction of Arrival) / DOD (Direction of Departure) characteristics. We have developed a rotating reflector antenna that can mechanically perform azimuthal beam scanning to enable DOA / DOD measurement in the 300 GHz band. In this report, we propose a DOA / DOD measurement method that uses the rotating reflector antenna as both the transmitter antenna (Tx) and the receiver antenna (Rx). In addition, experiments using our measurement method were conducted in a shielded room in a multi-reflection environment, and its effectiveness was confirmed by comparison with ray-trace simulating.

14:20 ***Impact of Test Zone Polarization-Imbalance on MIMO Efficiency in a Random-LOS OTA Setup***

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

Presented is an evaluation of the impact of the power imbalance between the vertical and horizontal polarization in the test zone of a random line-of-sight over-the-air characterization system on multiple-input multiple-output efficiency.

14:40 ***Development and Verification of Double-Directional Channel Sounder at 300 GHz***

Riku Takahashi, Kosuke Shibata and Minseok Kim (Niigata University, Japan)

This paper describes the 300 GHz channel sounder measurement system developed for Beyond 5G radio access systems. It also presents the results of double-directional channel measurements in a laboratory environment to validate the developed system. The measurement results show that several dominant multipath components were measured, and the angles of departure and arrival (AoD and AoA) were also in good agreement with those expected paths.

15:00 ***V2V Dynamic Channel Characterization in 5G mmWave Band***

Joseph Hoellinger (CEA-LETI, Université Grenoble Alpes, France); Gloria Makhoul (CEA-LETI & Université Grenoble Alpes, France); Raffaele D'Errico (CEA, LETI & Université Grenoble-Alpes, France); Thierry Marsault (DGA-MI, France)

This article presents the preliminary results of vehicle-to-vehicle measurements carried out at 26 GHz in suburban and urban environments considering different dual mobility patterns. The results are presented in forms of time-varying power delay profile, path loss and delay spread.

RS25: Gain Enhancement Techniques and High Gain Antennas

Room: C3.6

Chair: Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia)

13:40 ***Simultaneous S/X 3.7 m-Diameter Earth Station***

Christophe Granet (Lyrebird Antenna Research Pty Ltd, Australia); Kerry Clapham and Robin McNeill (Space Operations New Zealand Ltd, New Zealand); Karl Verran (KS Verran, Australia); John Kot (Young & Kot Engineering Research, Australia)

The design of a simultaneous S/X 3.7 m diameter earth station is presented. The project is described from its initial set of urgent requirements to the design, manufacture, and test phases.

14:00 ***Very Low-Profile and High Aperture Efficiency Fabry-Perot Cavity Antenna***

Seong Ju Kim (Sejong University, Korea (South)); Young-Geun Jeon (University of Sejong, Korea (South)); Han-jun Maeng and Dongho Kim (Sejong University, Korea (South))

14:20 ***A High-Gain Single-Layered Circularly Polarized Spiral Series-Fed Patch Antenna Array***

Nghia Nguyen-Trong (University of Adelaide, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

This paper shows a high-gain single-layered circularly polarized 2-dimensional (2D) series-fed patch antenna array. One fundamental problem of leaky-wave antennas and series-fed antennas is that the efficiency can degrade quickly when the antenna is designed for higher gain with a larger size. This is due to the fact that the leakage rate needs to be reduced while the loss rates remain constant. We will demonstrate that with the spiral configuration, this issue can be easily resolved with one simple alteration of the feeding, namely the addition of a radial power divider in the array center feed.

14:40 ***Design Method of a High-Directivity Corner Fabry-Perot Cavity Antenna Using a Conformal Mapping***

Gwang-Ro Yun and Young-Geun Jeon (University of Sejong, Korea (South)); Dongho Kim (Sejong University, Korea (South))

15:00 ***Radiation Pattern of a Radially Arranged Array in Relation With the Number of Linear Arrays***

Tadashi Takano (Nihon University & JAXA, Japan)

The radiation of an array antenna that is composed of linear arrays in radial arrangement is analyzed changing the number of the linear arrays. It is verified that the characteristics are greatly dependent on the number of linear arrays, and is well illustrated with a two-dimensional diagram of contour. The angular limitation to give the sinc pattern are clarified. Outside the limitation, there exist unwanted side lobes that are featured with high level and wide beam width.

Thursday, November 3 15:20 - 15:50 (Australia/Sydney)

Afternoon Tea

Thursday, November 3 15:50 - 17:30 (Australia/Sydney)

RS26: mm-Wave and THz Technologies

Room: C3.3

Chair: Mohammad Alibakhshikenari (Universidad Carlos III de Madrid, Spain)

15:50 ***Series-Fed Printed-Dipoles With a Director for Substrate Lateral Radiation***

Takuichi Hirano (Tokyo City University, Japan)

The use of the 300 GHz band is considered for next-generation wireless communication. Considering the integration of the RF front end and the antenna, it is preferable to integrate the antenna on the substrate. A series-fed printed-dipole with a director is presented in this paper. An antenna that radiates in the lateral direction of the substrate was designed by simulation. The relative frequency bandwidth was 41% for the reflection coefficient below -10 dB. A maximum gain of 7.5 dBi was obtained in the lateral direction of the substrate.

16:10 ***Measurement of a 60-GHz-Band Digital Beamforming Array Using 4-By-2 Circular Patch***

Satoshi Yoshida, Mizuki Kuwata and Kenjiro Nishikawa (Kagoshima University, Japan)

In this paper, a 60-GHz-band dual-polarized digital beamforming array antenna using circular patch is experimentally demonstrated. If two feed pins are used for real usage, we can obtain the 10 dBi beam coverage area of 360◦ in ϕ and 0 - 60◦ in θ by using the coordinate system shown in Fig. 3. Based on the measurement result, we show that beamforming coverage area can be expanded by the synthesis of dual-polarized configuration with beam switch operation.

16:30 ***Uniform Overlap Feeding Network to Reduce the Number of Phase Shifters in Scan Arrays***

Maryam Shadi (Tarbiat Modares University, Iran); Mohammad Reza Tavakol (Sharif University of Technology, Spain); Farhad Arpanaei and Mohammad Alibakhshikenari (Universidad Carlos III de Madrid, Spain); Francisco Falcone (Universidad Publica de Navarra, Spain)

A new phased array feeding network that minimizes the number of phase shifters over a limited scan is illustrated. The presented concept groups the primary phased-array elements into sequences of uniform overlap

sub-arrays that employ a single phase-shifter for each sub-array. Besides, using overlapped elements reduces the distance between secondary array elements and increases the array's gain. The proposed uniform overlap feeding network consists of some Wilkinson power dividers and T-junction combiners to excitation microstrip array antenna in 28GHz, simulated in the CST. The 16-elements linear array antenna uses seven phase-shifter (reducing more than 50% in the number of phase shifters) to scan up to 30◦ with SLL lower than 15dB. As reported, all input ports have a good matching, lower than 15dB, and high isolation around 25dB.

16:50 ***Design of Millimetre-Wave Passive Mixer in 45-nm SOI CMOS Technology***

Jim Darrell D Ang (University of Technology Sydney, Australia); Jefferson A. Hora (MSU-Iligan Institute of Technology, Australia); Xi Zhu (University of Technology Sydney, Australia)

Design of a millimetre-wave passive mixer in 45-nm SOI CMOS technology is presented in this work. To balance the conversion loss of the mixer with linearity, bias conditions are carefully selected. Moreover, transformer baluns are used to convert single-ended signal to differential ones for both LO and RF ports. Based on the electromagnetic simulations, the designed mixer has a return loss better than -10 dB for the RF port, and the conversion loss of the designed mixer is 10 dB, while a 14-dBm LO power is used. Meanwhile, under the same LO power, the P1dB of the designed mixer is -10 dBm. The overall size of the designed mixer with all RF and DC pads is only 0.95 × 0.6 mm 2.

17:10 ***Design of Millimetre-Wave Low-Noise Amplifier in 130-nm SiGe HBT Technology***

Jim Darrell D Ang (University of Technology Sydney, Australia); Jefferson A. Hora (MSU-Iligan Institute of Technology, Australia); Xi Zhu (University of Technology Sydney, Australia)

Design of a millimetre-wave low-noise amplifier (LNA) in 130-nm SiGe HBT technology is presented in this work. To balance the design trade-offs between NF and linearity, the bias voltage is carefully selected. Based on the electromagnetic simulations, the designed LNA has a small-signal gain of 20 dB and S11 is better than -14 dB at 20 GHz. The NF is lower than 2.5 dB and the input P1dB is -15 dBm. The overall size of the designed mixer with all RF and DC pads is only 1 ×0.75 mm2.

RS27: Investigation of New Materials and Measurement of Particular Antenna Characteristics

Room: C3.4

Chair: Ruolei Xu (National University of Singapore, Singapore)

15:50 ***Experimental Study of Site-VSWR Method for Radiated Emission Test Sites Above 18 GHz***

Se-ho Park (Korea Radio Promotion Association, Korea (South)); Hongsik Keum (RAPA, Korea (South)); JeongHwan Kim (Institute of Calibration & Technology Co. Ltd, Korea (South)); Sung-il Bang (Department of Electronics and Electric Engineering, Korea (South))

With the development of various wireless communication services such as 5G and Wi-Fi6E, the use of frequency bands above 6 GHz is increasing. For this reason, International Electrotechnical Commission (IEC) develops the measurement method of electromagnetic disturbance and test site validation above 18 GHz. This paper explores the site validation from 18 GHz to 40 GHz using the Site-VSWR method and evaluates the relation between S-VSWR value and the transmitting antenna positions. From the results, the transmitting antenna position does not affect the S-VSWR value.

16:10 ***An Accurate and Simple Method for Measurement of RF Characterization in Thin Substrate***

Sang Hyuck Han (Korea Advanced Institute Science and Technology, Korea (South)); Ikhwan Kim, Ju-Ik Oh, Hyo-Won Lee and Seong-Jin Kim (KAIST, Korea (South)); Jong-Won Yu (Korea (South))

16:30 ***The Effect of Raindrops on the Automotive On-Glass Antenna***

Takafumi Kikuchi (Tokyo University of Agriculture and Technology, Japan); Osamu Kagaya and Keisuke Arai (AGC Inc., Japan); Takuji Arima (Tokyo University of Agriculture and Technology, Japan); Toru Uno (Tokyo University of Agricultural Technology, Japan)

In this paper, we evaluate the effect of raindrops on the on-glass antennas in order to make the design more efficient. Automotive glass has a three-layer structure with an interlayer film in between to prevent shattering. A dipole antenna was placed on the lower center surface of a 300 mm × 300 mm glass sheet, and the electromagnetic field analysis was conducted using a model in which raindrops adhered to the antenna. The results show that raindrops have little effect on the reflection coefficient of the antenna. However, if the

raindrops flow in the same direction as the antenna and form streaks, the reflection coefficient worsens. Both raindrops and rain streaks were found to affect the radiation pattern.

16:50 ***Electromagnetic Shielding Using Graphene Material in Wide Bandwidth of 1.5GHz - 10GHz***

Kamal Gupta (Defence Science and Technology Organisation, Australia); Md J. Nine (The University of Adelaide, Australia); Craig Denton (Defence Science and Technology Group, Australia); Dusan Losic (The University of Adelaide, Australia)

We report pristine graphene (pG) as an effective shielding material for electromagnetic interference (EMI) in electronics, and RF sensor systems. The pG was produced via a simple process of mechanical exfoliation of natural graphite. The performance of as-prepared graphene film coating alone with a thickness of 27.9µm.was evaluated in terms of shielding effectiveness (SE) and demonstrate SE ~ 22.7dB-16.7dB in 1.5GHz-10GHz frequency band. The insertion loss through the alumina substrate was subtracted from the measurement result.

17:10 ***Leaky Wave Antenna Design by Loading Radiating Elements to an Asymmetrical SSPP Line***

Somia Sharma (IIT Delhi, India); Rajesh K Singh (Defence Institute of Advanced Technology Pune, India & DIAT Pune, India); Ananjan Basu (Indian Institute of Technology, Delhi, India); Shiban K Koul (Indian Institute of Technology Delhi, India)

In this paper, a leaky-wave antenna is designed by loading radiating elements to one side of the asymmetrical corrugated spoof surface plasmon polariton (SSPP) transmission line. The effect of loading patches only on corrugated side, uncorrugated side and both the sides of the asymmetrical corrugated SSPP line is studied. The advantage of using asymmetrical corrugated SSPP line is the reduction in the width of the line. Antenna with loaded patches on corrugated side, uncorrugated side and both side, operates in the frequency range 8.5-11 GHz, 8.5-10 GHz and 8-11 GHz with maximum gain of 13.2 dBi, 12.5 dBi and 15.7 dBi and scan range of 63^0, 36^0 and 77^0 respectively. This study tells that the loading of patches on corrugated side provides the better gain and scan range compared to other two cases.

RS28: Analytical and Computational Methods

Room: C3.5

Chair: John Kot (Young & Kot Engineering Research, Australia)

15:50 ***TEM-Wave Propagation Over a Graded Periodic RHM-LHM Composite in a Coaxial Waveguide***

Balwan Rana and Mariana Dalarsson (KTH Royal Institute of Technology, Sweden)

In this paper, we perform analytical and numerical studies of TEM-wave propagation in a coaxial waveguide filled with a graded periodic RHM-LHM composite, for which the real parts of the effective permittivity and permeability vary along the propagation direction (chosen to be the z-direction) according to an arbitrary periodic function. We obtain an excellent agreement between analytical and numerical results in the important special case of abrupt transitions between the two materials.

16:10 ***On the Equivalence Between Geometry and Material Properties in Maxwell's Equations***

John Kot (Young & Kot Engineering Research, Australia); Jeanne Young (YK Engineering Research, Australia)

The well-known equivalence between Maxwell's equations in curvilinear coordinates and the Cartesian form of Maxwell's equations for non-uniform material properties is formulated in the language of differential forms. The equivalence emerges from this formulation in a very simple and transparent way.

16:30 ***Field Theoretic Analysis of a Four Port Narrow Wall Directional Coupler***

Ashmi Chakraborty Das (Indian Institute of Technology (ISM), India); Santanu Dwari (Indian Institute of Technology (ISM) Dhanbad, India)

In this paper, the analysis of a four-port narrow wall directional coupler has been has been presented using multiple cavity modeling technique. The field propagation between the ports of the network has been described in terms of aperture field distributions. The analysis has been verified by comparing the simulated scattering parameter data with the measured data available in literature.

16:50 ***Surface Integral Equation Based Characteristic Mode Analysis of Dielectric Objects***

Jihong Gu (National University of Singapore, Singapore); Shaode Huang (Chongqing University, China); Chao-Fu Wang (National University of Singapore, Singapore)

This paper presents how to apply surface integral equation (SIE) based characteristic mode (CM) formulation to study the underlying physics of the CMs of dielectric material bodies. It is observed that the modal solution results obtained using SIE based CM formulation are very helpful to understand electromagnetic behavior of the dielectric material bodies.

17:10 ***Ray-Tracing Analysis of Double-Layer Geodesic Lens Antenna***

Qiao Chen (KTH Royal Institute of Technology, Sweden); Francisco Mesa (University of Seville, Spain); Oscar Quevedo-Teruel (KTH Royal Institute of Technology, Sweden)

A double-layer geodesic lens consists of two layers of flat or curved parallel-plate waveguides, connected by a mirror over part of their common periphery. Such a device can provide one focus on each layer, and a wave is transformed across layers between the two foci. When one of the foci is at infinity, the lens can be used as an antenna that permits a direct extension for two-dimensional scanning with low scan losses. Here, we carry out a ray-tracing analysis of a rotationally symmetric double-layer geodesic lens antenna with one of its two layers being flat. The proposed model demonstrates good computational efficiency and agrees well with the simulated/measured results.

RS29: Waveguides and Waveguide-Based Antennas

Room: C3.6

Chair: Takashi Tomura (Tokyo Institute of Technology, Japan)

15:50 ***Groove Gap Waveguide With Interlaced Pins for Higher-Frequency Fabrication***

Yaxiang Wu, Jiro Hirokawa and Takashi Tomura (Tokyo Institute of Technology, Japan)

Gap waveguide is attractive for millimeter-wave and terahertz-wave devices for its low-loss transmission. However, the fabrication would be difficult if the periodic pins that generate electromagnetic bandgap are closely spaced and thin, especially at a high frequency. This manuscript presents a groove gap waveguide, where interlaced pins are extended from both top and bottom plates to maximize the use of space and enlarger the space between the pins for reducing the fabrication difficulty. To demonstrate the feasibility, the dispersion property of the unit cell is analyzed and two parallel H-plane groove gap waveguides separated by two rows of interlaced pins are simulated.

16:10 ***Bandwidth Extension of GSCPW-To-Waveguide Transition in Multi-Layer Dielectric Substrate by Corrugation Structures in THz Band***

Chatchai Chokchai, Henry Abu Diawuo, Yoshiki Sugimoto, Kunio Sakakibara and Nobuyoshi Kikuma (Nagoya Institute of Technology, Japan)

This paper proposes the bandwidth extension of a grounded suspended coplanar waveguide (GSCPW)-to-waveguide transition in a multi-layer dielectric substrate by use of corrugation structures in the THz band. A rectangular patch element is used to transmit to the waveguide. Concurrently, the corrugation structures are applied at the edges of the aperture on the middle layer to improve the transmission characteristics and extend the bandwidth. The bandwidth of S11 below -10 dB and S21 higher than -3 dB of the proposed multi-layer GSCPW-to-waveguide transition was 58.9 GHz and 52.8 GHz, respectively. The corrugation structures can extend the bandwidth up to 12.2% compared to the transition without corrugation.

16:30 ***Air-Filled SIW Antenna for High Gain SmallSat Applications***

Ratul De (Indian Institute of Technology Delhi, India); Mahesh P Abegaonkar and Ananjan Basu (IIT Delhi, India)

This article demonstrates the design of an empty/Air filled SIW cavity backed dual slot antenna at 15 GHz. Air cavity is created by removing the substrate inside the SIW structure to increase the gain. Possibility of array using the proposed antenna is also being explored. The antenna can be used in Ku band high gain small satellite applications.

16:50 ***Differential Feeding for High-Gain Low Side Lobe Slotted Waveguide Array Antenna in High Power Applications***

Phong Nguyen Duy and Duc Phu Phung (Viettel High Technology Industries Corporation, Vietnam);

Binh Nguyen (Viettel Research & Development Institute, Vietnam); Tien Manh Nguyen (Viettel High Technology Industries Corporation, Vietnam)

This paper introduces a planar slotted waveguide array antenna with 12×12 elements for generating high energy beams. Differential feeding technique and cavity surface are employed to broaden the impedance bandwidth as well as the antenna performance. The high-gain and low side lobe level (SLL) are achieved by utilizing the 25-dB Taylor array synthesis method. Simulation results indicate that the array antenna has the impedance bandwidth from 2.85 GHz to 3.15 GHz (fractional bandwidth of 10%), the maximum realized gain of 29.3 dB at 3.0 GHz and the sidelobe level of -24.7 dB, becoming a potential candidate for high power applications.

17:10 ***Ridge Gap Waveguide Based Slot Antenna Array for Point to Point Wireless Communication***

Shozab Shafiq (Beijing Institute of Technology, China)

A millimeter-wave, corporate fed slot antenna array based on ridge gap waveguide technology is presented. It consists of three metal layers separated by a small gap. The antenna sub-array comprises four cavity-backed slots arranged symmetrically in a grid-shaped pattern. This sub-array is a unit cell for a planar array. The top layer consists of radiating slots surrounded by an octagonal cavity to minimize mutual coupling between the slots and avoid grating lobes. In the middle, there is a cavity layer that increases the impedance bandwidth of the antenna, and at the bottom there lies a feed network layer that is built on ridge gap waveguide technology. Periodic circular-shaped metal pins confine the input power both in the cavity layer as well as in the distribution layer within the prescribed paths. Equal power dividers are used for uniform excitation to keep amplitudes and phases equal at all output ports. The proposed antenna array has a relative impedance bandwidth of 11.3% with an input reflection coefficient better than -10dB from 58 GHz to 65 GHz frequency range.