ISAP2015 Technical Program

Time	Tasman A	Wellington 1	Wellington 2
Monday, November 9			
09:00-10:30	T1.1: Tutorial 1 - Practical Applications of Asymptotic Techniques in Electromagnetics	T2.1: Tutorial 2 - Measurements as Field Sources in Computational Electromagnetics with Application in Antenna Placement Analysis and EMC	T3.1: Tutorial 5 - Stepped Plane Wave Simulation for some common antenna problems using exising simulation software
		Morning Tea	
11:00-12:30	T1.1: Tutorial 1 - Practical Applications of Asymptotic Techniques in Electromagnetics	T2.1: Tutorial 2 - Measurements as Field Sources in Computational Electromagnetics with Application in Antenna Placement Analysis and EMC	T3.1: Tutorial 5 - Stepped Plane Wave Simulation for some common antenna problems using exising simulation software
		Lunch on your own	
13:30-17:00	T1.2: Tutorial 4 - Towards Energy-Efficient Hyper-Dense Wireless Networks with Trillions of Devices	T2.2: Tutorial 3 - OTA testing of Wireless Devices in RIMP and Random-LOS: Preparing for 5G Wireless Systems	
		Afternoon tea	
13:30-17:00	T1.2: Tutorial 4 - Towards Energy-Efficient Hyper-Dense Wireless Networks with Trillions of Devices	T2.2: Tutorial 3 - OTA testing of Wireless Devices in RIMP and Random-LOS: Preparing for 5G Wireless Systems	

Time	Tasman A	Tasman B	Tasman C	Wellington	Auditorium
Tuesday, November 10					
08:00-10:20	S1.1: Multi-band and wide-band antennas I	S2.1:Millimeter-wave antennas and devices I	S3.1:Antenna arrays I	S4.1: Small antennas I	S5.1: Antennas for biomedical and healthcare applications
Morning Tea					
10:40-11:30					S5.2.1: Keynote 1 - Antenna and Wireless Technologies for Safeguading Australia
11:30-12:20					S5.2.2: Keynote 2 - Recent Medical Applications of Antennas
Lunch					
13:00-15:20	S1.3: Metamaterials	S2.3:Metamaterial and THz antenna research in Europe	S3.3:Millimeter wave and THz antennas	S4.3: Microwave techniques for medical diagnostic and therapeutic applications I	S5.3: Reconfigurable antennas I
Afternoon Tea					
15:40-18:00	S1.4: Multi-band and wide-band antennas II	S2.4: Wireless power transmission and energy harvesting	S3.4:Antenna arrays II	S4.4: Microwave techniques for medical diagnostic and therapeutic applications II	S5.4: Reconfigurable antennas II
Break					
19:00-22:00	Welcome Reception - Exhibition Foyer				

Time	Tasman A	Tasman B	Tasman C	Wellington	Auditorium
Wednesday, November 11					
08:00-10:20	S1.5: Computational electromagnetics I	S2.5: Mobile and indoor propagation I	S3.5: Radar and satellite systems I	S4.5: EBG, metamaterials and periodic structures I	S5.5: RFID and wireless sensing I
Morning Tea					
10:40-11:30					S5.6.1: Keynote 3 - The Mesmerizing Evolution of Reflector Antennas in Diverse Applications: A Passage from the Ancient Past to the Renaissance and the Present
11:30-12:20					S5.6.2: Keynote 4 - Antennas and Quasi-optics For Space Terahertz Instrumentation
Lunch					
13:00-15:20	S1.7: Microwave imaging for biomedical and other applications I	S2.7: Phased arrays and smart antennas	S3.7:Antennas for 4G/5G applications	S4.7: Miniaturized antennas for communications	S5.7: Multiband and wideband antennas, and emerging antenna technologies
Afternoon Tea					
15:40-18:00	S1.8: Microwave imaging for biomedical and other applications II	S2.8: Diversity antennas, MIMO antennas and systems	S3.8:Antenna measurements I	S4.8: Novel materials for RF devices	S5.8: Radio wave propagation I
Break					
19:00-22:00	Conference Banquet - Derwent Room				

Time	Tasman A	Tasman B	Tasman C	Wellington	Auditorium
Thursday, November 12					
08:00-10:20	S1.9: Antennas for base stations and handheld devices	S2.9: Multi-band and wide-band antennas III	S3.9: Small antennas II	S4.9: Millimeter-wave antennas and devices II	S5.9: Antenna arrays III
			Morning Tea		
10:40-11:15	S1.10.1 - Invited: Broadband 3D metamaterial carpet cloak			S4.10.1 - Invited: Enhancing the sports experience: Electromagnetics for Fun, Profit & Audience Engagement	S5.10.1 - Invited: Reconfigurable Magneto-electric Dipole Antennas
11:15-11:50	S1.10.2 - Invited: Metamaterial-Based Electromagnetic Space, Time and Spacetime Dispersion Engineering			S4.10.2 - Invited: Advanced Phased Arrays and Reflector Antennas for 21st Century Satellite Communication Payloads	S5.10.2 - Invited: Metamaterial-Inspired Electrically Small Antennas Integrated Into Structural Materials
11:50-12:25	S1.10.3 - Invited: MetaLine, MetaSpiral, and MetaHelical Antennas			S4.10.3 - Invited: Developing 5G for Mission Critical Machine Communications	S5.10.3 - Invited: Meta-Atom Materials for RF Microwave Substrates Using Additive Manufacturing (3D Printing)
			Lunch		
13:00-15:20	S1.11: Antenna measurements II	S2.11: Computational electromagnetics II	S3.11: Microwave and RF devices I	S4.11: Radio wave propagation II	S5.11: RFID and wireless sensing II
			Afternoon Tea		
15:40-18:00	S1.12: Radar and satellite systems II	S2.12: Diversity and MIMO	S3.12: Microwave and RF devices II	S4.12: EBG, metamaterials and periodic structures II	S5.12: Diverse antenna applications
18:00			ISAP2015 Conference Close		

Monday, November 9

09:00 - 12:30

T1.1: Tutorial 1 - Practical Applications of Asymptotic Techniques in Electromagnetics

Prof. Francisco Saez de Adana, Department Of Computer Science, Universidad de Alcala, Spain.
Room: Tasman A

The asymptotic techniques have been widely used for solving electromagnetic problems when the electrical size of the scenario is large in comparison to the wavelength. These techniques are applied to problems such as the analysis of on-board antennas, computation of the RCS, antenna design or the study of the propagation in mobile communications. However, the accuracy of these techniques is related to the fidelity of the geometrical modeling compared to the real scenario. There are two options. The first option is a simplification of this modeling using canonical structures to simplify the geometrical treatment associated with these techniques. The disadvantage of this option is a loss of accuracy in the results. The second option is an exact modeling of the scenario in order to obtain results that are as accurate as possible. In this case, the price to pay is the computational cost associated with the solution of the problem. This tutorial attempts to show how this second modelling option can be applied to obtain very accurate results; combining the electromagnetic techniques with some geometrical techniques enables the solution of realistic and complex problems with a reasonable amount of computational resources.With this aim, the tutorial presents the application of high frequency or asymptotic techniques to the analysis of complex electromagnetic problems. By complex problems we refer to those that are completely arbitrary in shape. A suitable geometrical modeling of the problem is then needed. This modeling is performed by means of parametric surfaces called NURBS (Non Uniform Rational B-Splines) that are commonly used in the world of Computer Aided Graphic Design for aeronautical and architectural applications. A description of this modeling is included in the tutorial. The main objective of the tutorial is the application of the asymptotic techniques to the analysis of problems modeled by these kind of surfaces. Two techniques are described: the Uniform Theory of Diffraction (UTD) and the Physical Optics (PO). The basic theory of both techniques is explained but with special focus on their applicability to objects modeled by NURBS. A section is also dedicated to the so-called ray-tracing acceleration techniques which are very important for addressing complex problems with a reduced computational cost. The application of these techniques to both UTD and PO are included in the tutorial.

T2.1: Tutorial 2 - Measurements as Field Sources in Computational Electromagnetics with Application in Antenna Placement Analysis and EMC

Lars Jacob Foged, Microwave Vision Group, Via Castelli Romani 59, 00040 Pomezia (RM), Italy
Room: Wellington 1

The source reconstruction, or equivalent source method, provides an accurate near-field representation of any radiating device in terms of equivalent electric and magnetic currents. The equivalent currents can be determined from measured near- or far-field data through a post-processing step involving the solution of an integral equation. The equivalent currents constitute an accurate 3D electromagnetic model, maintaining near and far field properties of the measured device. A newly created link, enable the import of such models into several commercial computational electromagnetic (CEM) solvers in the form of a near-field Huygens box.The tutorial cover the application of the link to the computational analysis of antenna placement on large structures, and electromagnetic compatibility (EMC) using commercially available near-field measurement systems, post-processing, and CEM tools. Application examples are discussed in detail:1. Antenna placements on larger complex structures,2. Pre-compliance emission analysis of a printed circuit board (PCB). Experimental validations of the computational processes are shown from measurement results.The tutorial covers the following topics:1. Introduction to the equivalent source/current method - Near Field measurement techniques - Equivalent source/current processing of near field data2. Huygens Box link to computational tools and validation scenarios3. Source antenna measurement and post-processing issues - "Free space" antenna source - Flush mounted antenna applications4. Application examples - Radiation of flush mounted small antenna in complex scenario - Emission analysis PCB board in realistic scenarios (EMC)5. Discussion, Next Steps and Conclusion

T3.1: Tutorial 5 - Stepped Plane Wave Simulation for some common antenna problems using exising simulation software

Reuben Shar & Christine Chen, Thales Australia
Room: Wellington 2

Traditional antenna simulations use active source or sources together with other structures and the solution finds the far or near electromagnetic (EM) field distributions. In some cases, it is useful to perform the inverse operation, which treats the antenna as a passive structure being excited by an external, controlled EM field. In far-field cases, the external controlled EM field used is a plane wave. This tutorial will demonstrate how this method can be applied using some existing EM simulation tools. Examples will include some common antenna problems, solved for comparison both in the 'traditional' method and the stepped external field method. Where time permits, some examples will be done as live simulations.

13:30 - 17:00

T1.2: Tutorial 4 - Towards Energy-Efficient Hyper-Dense Wireless Networks with Trillions of Devices

Abolfazl Mehbodniya, Wireless Signal Processing and Networking Laboratory, Graduate School of Engineering, Dept. of Communications Engineering, Tohoku University & Fumiyuki Adachi, Wireless Signal Processing and Networking Laboratory, Graduate School of Engineering, Dept. of Communications Engineering, Tohoku University
Room: Tasman A

The information and communication technology (ICT) data traffic is expected to increase 1,000 fold by 2020. This increasing demand is quickly draining the scarce radio resources and will eventually affect our nations' economy. This strongly motivates the need for intensive research on the next generation of wireless networks. Beyond conventional cellular data, machine-to machine (M2M) and device to device (D2D) communication will be responsible for a big portion of the wireless traffic in the next few years. This will, in turn, further strain existing wireless infrastructure and require novel designs. According to recent forecasts, there will be 12.5 billion inter-connected machine-type devices worldwide by the year 2020, up from 1.3 billion in 2012. For coping with such traffic growth, it is well known that the major technique for meeting a much needed 1000x capacity improvement will be a byproduct of massive network densification. The idea is to introduce heterogeneous networks (HetNets) having new, additional nodes, such as small cellbase stations, deployed within local-area range and making the network closer to the end-users. The integration of macro/micro/pico/small cell base stations (SBSs) with disparate cell sizes and capabilities, has already been approved as a working item in LTE-advanced and 5G. Such hyper-dense and heterogeneous networks (HDHNs) can significantly improve spatial frequency reuse and coverage, thus meeting the wireless capacity crunch. For example, it is envisioned that a viral and hyper-dense deployment of low-cost small cells in the near future, with 200-300 small cells per typical macro cell coverage, approaching one-to-one ratio with the number of UEs. Such HDHNs are characterized by two unique features: a) massive number of devices and b) highly dynamic environment. How to manage, operate, and optimize such hyper-dense, dynamic networks, in an energy-efficient and sustainable manner, is an important research challenge that has recently received significant research interest from both academia and industry. The main goal of this tutorial is to introduce different aspects of designing HDHNs with advanced capabilities while focusing on spectral-efficiency (SE) and energy-efficiency (EE). In particular, we will introduce a plethora of techniques that include stochastic geometry, fuzzy logic, and game-theory that are necessary for deploying and operating large-scale, self-organizing HDHNs that can be used to support various communication systems with seamless mobility.

T2.2: Tutorial 3 - OTA testing of Wireless Devices in RIMP and Random-LOS: Preparing for 5G Wireless Systems

Per-Simon Kildal, Chalmers University of Technology, Sweden & Andrés Alayón Glazunov, Chalmers University of Technology, Sweden
Room: Wellington 1

The reverberation chamber has through the last fifteen years been used to emulate a rich isotropic multipath (RIMP) environment, and it has successfully demonstrated its ability to test Over-The-Air (OTA) performance of multiport antennas and active wireless devices. The latter include e.g., handsets, laptops and small base stations. The measured throughputs of practical 4G LTE devices with MIMO and OFDM capabilities have been shown to be in excellent agreement with basic theoretical algorithms. Now is the time to use this concept to provide a complete characterization of the OTA performance to cover all real-life environments. This is naturally done by introducing the pure LOS (Line-Of-Sight) as a complementing limiting edge environment, and by taking into account the statistics of the randomness introduced by users. The latter plays a major role in pure LOS that thereby rather becomes a random LOS environment. The two limiting environments are linked together through a pragmatic real-life hypothesis, and work has started to test this by simulations.It will be shown that the fundamental characterizing quantity becomes the probability of detection of single or multiple bit streams (for diversity and multiplexing cases, respectively) over an ensemble of users. This probability of detection becomes equal to a relative throughput in a multipath environment, readily seen through the simple threshold receiver model representing an ideal digital receiver.The new approach represents a way to optimize the wireless networks by taking the statistics of users into account. This will be particularly important for the next Fifth Generation (5G) wireless systems, which will extend to higher frequencies at which the Random-LOS gets increased relevance and thereby importance too. The Random-LOS OTA testing is already in 4G very relevant for automotive applications, and the tutorial will show the first verification of automotive Random-LOS experimental OTA test setups.

08:00 - 10:20

S1.1: Multi-band and wide-band antennas I

Room: Tasman A

Chairs: Edson Santos (Universidade Presbiteriana Mackenzie, Brazil), Luca Scorrano (Elettronica S.p.A., Italy)

08:00 *A Novel Ultra-Wideband UHF Low-Profile Monopole for UAV Platforms*

Luca Scorrano (Elettronica S.p.A., Italy); Antonio Manna (Elettronica SpA, Italy); Daniele Spaziani, Fabrizio Trotta, Pasquale Naglieri and Mauro Ferrari (Elettronica S.p.A., Italy)

In this contribution, a novel low-profile blade monopole is presented, working in the 500-2500 MHz frequency band. The simple yet effective design is such to grant both physical strength and stable performances in terms of radiation pattern over the entire working frequency band, confirming this antenna as an excellent candidate for high precision Direction-Of-Arrival (DOA) avionic systems. Experimental results as well as design details will be possibly presented at the conference.

08:20 *Novel Internal High Gain Loop Handset Phone Antenna Design for Satellite and Terrestrial Integrated Mobile Communications System Applications*

Wei-Yu Li and Wei Chung (Industrial Technology Research Institute, Taiwan); Hiroyuki Tsuji (NICT, Japan); Amane Miura (Institute of Information and Communications Technology, Japan)

This article presents a novel internal high-gain handset phone antenna design for STICS system application. STICS is the Satellite and Terrestrial Integrated Mobile Communication System in the 2GHz band in Japan. This article demonstrates that 1.5 wavelength folded loop radiator is a very promising antenna solution for the future STICS mobile phone terminals for satellite-link functions. The proposed antenna can be closely integrated at the top side-edge of a corner of a handset ground plane with an internal-type and low-profile antenna size (3 mm height only protruded from the side-edge). A broadside fan-shape radiation pattern toward the sky can be formed successfully by the proposed antenna in the desired 2GHz band. Besides, the radiation pattern can achieve a wide coverage with 3 dB beamwidth over 150 degree and peak antenna gain over 4.5 dBi in the vertical plane cross the handset ground plane. The constructed prototype has been studied in this paper.

08:40 *A Simple Monopole Antenna for Hepta-band LTE/WWAN Metal-framed Mobile Phone*

Dongho Lee (Yonsei, Korea); Woo Cheol Choi and Young Joong Yoon (Yonsei University, Korea)

A simple monopole antenna for hepta-band LTE/WWAN (824 ~ 960/1710~2690 MHz) Metal-framed mobile handset is proposed. Two slits are applied at the upper part of the metal frame. And the metal frame between slits is used for monopole antenna itself. The proposed monopole antenna structure is simple, slim and it has just one feed-line. For producing multiple resonances, impedance matching methods with lumped elements are used. Shunt chip inductor, chip capacitor matching circuit generates resonant modes at 850 MHz and 1700MHz. Band-stop matching circuit and the coupling effect between the metal frame and the antenna widen the low and high frequency bandwidth respectively. Thus, the proposed antenna covers GSM850, GSM900 (824~960 MHz) and GSM1800, 1900, UMTS2100, LTE2400, 2600 (1710~2690 MHz)

09:00 *A Wideband Microstrip Monopolar Patch Antenna with Compact Size*

Wang Kai Xu and Hang Wong (City University of Hong Kong, Hong Kong); Jun Xiang (Information and Communication Technology Centre, Shenzhen Research Institute, P.R. China)

A compact monopolar patch antenna is presented in this paper. The antenna has a wide bandwidth and a monopole-like radiation pattern. To reduce the whole size of the antenna, a substrate with high dielectric constant is adopted. Besides, three types of shorting pins and a triangle slot are added to the patch to widen the impedance bandwidth. The proposed antenna operates from 2.29 to 2.59 GHz for the reflection coefficient ≤ -10 dB and has the maximum gain of 3.5 dBi. Most important, the antenna is low profile which only has the height of 0.048 λ0

09:20 *Dual-Band Slot Antenna with Metal Surroundings for WBAN Applications*

Wonseok Lee and Jaehoon Choi (Hanyang University, Korea)

A dual-band slot antenna with metal back-cover and metal rim for WBAN applications is proposed. A T-shaped coupled feed structure on FR4 substrate is placed under the metal back-cover and surrounded by an unbroken metal rim. A slot antenna operating at 2.45 GHz is designed first on the metal back-cover and two parasitic elements nearby the feed structure are added to enhance the bandwidth in 2.45 GHz ISM band by exciting TM11 mode on the ground plane. Another parasitic element nearby the feed structure is used to cover 5.8 GHz ISM band. Then, additional two shorting strips between the metal back-cover and the surrounding metal rim are applied to control current flows properly in 2.45 GHz and 5.8 GHz ISM bands. The proposed antenna satisfies required bandwidths in 2.45 GHz and 5.8 GHz ISM bands. In addition, the radiation pattern of the proposed antenna is outward directional on the human equivalent flat body phantom, which is desirable for WBAN applications.

09:40 *A Wideband Antenna with Characteristics for DVB-T*

Edson Santos (Universidade Presbiteriana Mackenzie, Brazil); Gunnar Bedicks Jr. and Cristiano Akamine (Mackenzie Presbyterian University(UPM), Brazil)

A wideband monopole antenna in a conical structure with a cylindrical element to promote the UHF band cover and indoor use is presented. Experimental results demonstrated that the proposed antenna can operate at the frequency band from 469MHz to 1387MHz which VSWR<2. The bandwidth of the proposed antenna cover the DVT-B, LTE700, GSM850, and GSM900 bands. The project was made to be a lower cost and easy construction. The antenna shows peak gain of 3.3dBi. In addition, simulation radiation patterns of the proposed antenna is presented. The measured results of a fabricated antenna agreed well with the simulation results. The proposed antenna has a simple structure and good performance and is a suitable candidate for digital TV applications.

10:00 *Design and Analysis of 3D Posts Based Antenna*
Putluru Sravani (IIIT-Bangalore, India); Gaurangi Gupta and A. r. Harish (Indian Institute of Technology Kanpur, India); Madhav Rao (IIIT-B, India)
Three dimensional (3D) antenna refers to an assembly of radiating element on one layer and feed line on another layer and was introduced to minimize the antenna design space. This configuration allows room to integrate more devices and thereby enhances the chip functionalities for an system on chip (SoC) radio frequency (RF) applications. The designed 3D antenna element is composed of vertical metal supports or posts and combination of copper pads connecting multiple supporters. The 3D posts based antenna was designed for 24 GHz ISM band applications and its performance was computed by changing the number of posts. The antenna performance was improved by the inclusion of novel 3D posts and the footprint of overall antenna design was reduced to 2.75 mm × 2.75 mm. To verify the architecture, a similar posts based antenna was fabricated for 2.5 GHz frequency and antenna performance was measured. Experimentally measured antenna parameters and simulated results were found to be in agreement.

08:00 - 10:00

S2.1: Millimeter-wave antennas and devices I

Room: Tasman B

Chairs: Haruichi Kanaya (Kyushu University, Japan), Takeshi Manabe (Graduate School of Engineeringl, Osaka Prefecture University, Japan)

08:00 *300 GHz One-Sided Directional Slot Array Antenna on Indium Phosphide Substrate*
Haruichi Kanaya, Tomoki Oda, Naoto Iizasa and Kazutoshi Kato (Kyushu University, Japan)
This paper presents a novel design of 300 GHz band 1 x 4 one-sided directional slot dipole array antenna fed by coplanar waveguide (CPW) on indium phosphide (InP). The proposed antenna has four antenna elements and branched CPW structure to achieve a high antenna gain and a sharp beam. We fabricated and measured the array antenna. In the EM simulation, forward directional peak gain is 7.35 dBi. The measured reflection coefficient is agreed with the simulation results.

08:20 *Dual-Polarization Jerusalem-Cross Slot Type FSS for a Submillimeter-Wave Band*
Takeshi Manabe (Graduate School of Engineeringl, Osaka Prefecture University, Japan); Ken-ichi Kikuchi (National Astronomical Observatory of Japan, Japan); Satoshi Ochiai (National Institute of Information and Communications Technology, Japan); Toshiyuki Nishibori (Japan Aerospace Exploration Agency, Japan)
A dual-polarization Jerusalem-cross slot array (JCSA) type frequency selective surface is designed for separating the submillimeter-wave band around 650 GHz in view of future application to spaceborne submillimeter-wave spectrometric radiometers. Based on this design, the JCSA type frequency selective surface is fabricated by applying a photolithographic process and gold plating to SiC substrate. The transmission and reflection characteristics measured for the fabricated JCSA agree well with those simulated by the method-of-moment calculation.

08:40 *140 GHz CMOS On-chip Dipole Antenna with Optimal Ion-Irradiated-Silicon with Vertical Reflector*
Junji Sato and Tomohiro Murata (Panasonic Corporation, Japan)
This paper presents the gain enhancement techniques for a 140 GHz CMOS on-chip antenna. The proposed CMOS on-chip folded dipole antenna is mounted on a metal plate which functions as a reflector. Furthermore, by using ion irradiation which increases the resistivity of the silicon (Si) substrate more than 100 ohms-cm, 5 dB of antenna gain enhancement is achieved. Fabricated in a 40 nm CMOS process, the proposed on-chip antenna shows excellent maximum antenna gain of -2.7 dBi at 140 GHz.

09:00 *High Efficiency 2×2 Cavity-Backed Slot Sub-array for 60 GHz Planar Array Antenna Based on Gap Technology*
Abbas Vosoogh and Per-Simon Kildal (Chalmers University of Technology, Sweden)
This paper presents a two layer 2×2-slot element as a sub-array for 60 GHz planar array antenna based on gap waveguide technology. The proposed element consists of 2x2 slots in a gap waveguide cavity where the cavity is fed through a coupling slot from a ridge gap waveguide corporate-feed network in a lower layer. The 2×2-slot sub-array is numerically optimized in an infinite array environment. The designed sub-array shows the relative bandwidth of 11% with reflection coefficient better than -13 dB over 58.2-65 GHz frequency band. A prototype of a 8×8-element slot array antenna is designed and fabricated in order to verify the simulations.

09:20 *Silica-based Post-Wall Waveguide with High-Performance Input and Output Transitions for E-band Passive Front-end*
Yusuke Uemichi, Osamu Nukaga, Kei Nakamura, Xu Han, Ryouhei Hosono and Ning Guan (Fujikura Ltd., Japan)
We proposed silica-based post-wall waveguides (PWWs) with input and output (I/O) transitions from microstrip line for 71-76 GHz and 81-86 GHz, respectively. The PWWs were designed so that their reflection keeps lower than -20 dB at the aimed frequencies. They were fabricated in silica substrates and the performance was measured. Realization of the bandwidth of 23.6% was confirmed at the lower band. The transmission loss of the sole PWW was 0.0326 dB/mm and the insertion loss of the transition was 0.25 dB, both at 85 GHz. The silica-based PWWs can offer a practical platform for passive front-end including antenna feeds in E-band.

09:40 *Computational Simulation of Millimetre Wave Radar with a Modified Ray Tracing Renderer*

Trevor G Anderson (University of Sydney & Australian Centre for Field Robotics, Australia); David G Johnson (University of Sydney, Australia)

In this paper a high fidelity simulator for millimetre wave (MMW) radar systems is obtained through the implementation of geometric diffraction methods within a physically-based ray tracing renderer. Our method is formulated on an implementation of Kouyoumjian and Pathak's compact dyadic diffraction coefficient within Pharr and Humphrey's physically based ray tracing renderer, "pbrt". A recursive path tracing algorithm is used to simulate light transfer between surfaces and a randomly-sampled Monte Carlo surface integrator is used to approximate the incident radiation at each surface intersection. The surface path throughput is determined by a micro-facet-based surface model augmented by Kouyoumjian and Pathak's diffraction coefficient evaluated with reference to proximity to and relative orientation of nearby edges. The presented method is validated by comparison to experimental radar measurements, whilst remaining able to simulate the complex light transport problem significantly faster than a full wave simulator on a consumer level PC.

08:00 - 10:20

S3.1: Antenna arrays I

Room: Tasman C

Chairs: Krzysztof Wincza (AGH University of Science and Technology, Poland), Fitri Yuli Zulkifli (Universitas Indonesia, Indonesia)

08:00 *Reduced Sidelobe Multibeam Antenna Array with Broadside Beam Fed by 4x8 Butler Matrix*

Krzysztof Wincza, Artur Rydosz, Izabela Slomian and Slawomir Gruszczynski (AGH University of Science and Technology, Poland)

A concept of sidelobe level reduction in multibeam antennas fed by 4 x N Butler matrices has been extended on multibeam antennas with broadside beam. It has been shown that by adding in-phase power dividers at the output of a Butler matrix ensuring ±90°, 0° and 180° differential phases and by increasing the number of radiating elements a significant sidelobe reduction can be achieved, similarly as in case of known multibeam antennas fed by modified Butler matrices. The presented concept has been confirmed by measurements of a multibeam antenna array consisting of eight radiating elements fed by 4 x 8 modified Butler matrix in which the achieved sidelobe level is as low as -22 dB.

08:20 *A Waveguide Slot Array Antenna with Integrated T-shaped Filters in the Corporate-feed Circuit*

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

In this paper, we demonstrate a waveguide slot array antenna by integration of T-shaped filters using the diffusion bonding of laminated thin metal plates. The excellent performance of the T-shaped filter has been experimentally verified by the in-band transmission and the out-of-band rejection of the fabricated antenna.The measured results show that greater than 70% antenna efficiency with higher than 31.5 dBi is achieved over the 71.3-84.7 GHz, while significant gain-reduction is observed outside the passband.

08:40 *Devising a Horizontal Chamber Array for Automotive OTA Tests in Random Line-Of-Sight*

Andrés Alayon Glazunov and Per-Simon Kildal (Chalmers University of Technology, Sweden); Madeleine Schilliger Kildal (Chalmers University of Technology & Bluetest AB, Sweden)

In this paper we propose an approach to design a horizontal array antenna to reduce the uncertainty of reference measurements in Random Line-Of-Sight Over-The-Air testing in anechoic chambers. The main focus is on wireless communications testing to and from automotive vehicles. The proposed procedure allows to determine the size, the spacing and the number of elements of a horizontal array antenna resulting in an absolute error less than 1 dB. The analysis is based on presenting the output of the ideal digital threshold receiver model of the device under test as a Probability of Detection curve.

09:00 *Planar Multi-layer Passive Retrodirective Van Atta Array Reflectors At X-band*

Kin Shing Bobby Yau (Defence Science and Technology Group, Australia)

Retrodirective array reflectors have found many applications in the area of collision avoidance systems, satellite communications and enhancing RCS in general. This paper presents two planar multi-layer passive retrodirective Van Atta array reflectors based on microstrip antenna operating at X-band. Theoretical analysis of the Van Atta array will be outlined, together with simulation results and RCS measurements of the planar Van Atta array reflectors. Future development in extending the bandwidth of the passive Van Atta array and further increase in RCS will also be discussed.

09:20 *Design of Butler Matrix Integrated with Antenna Array for Beam Forming*

Fitri Yuli Zulkifli, Nurul Chasanah and Basari Basari (Universitas Indonesia, Indonesia); Eko Tjipto Rahardjo (University of Indonesia, Indonesia)

This paper introduced the 4x4 Butler matrix as the beamforming network combined with 4 linear aperture coupled antenna arrays to produce four narrow steerable beams. The designed was aimed for resonance frequency 2350 MHz in application of LTE technology using the Advance Design System (ADS) simulator and CST Microwave Studio Simulator. The measurement result shows that the bandwidth for each port is about above 100 MHz. Isolation loss in the range frequency 2.3 - 2.4 GHz is from -20 dB until -62 dB. When port 1, 2, 3, or 4 is activated, the beamwidth is 33.8°, 39.8°, 40.3°, 35.6° with gain 6.11 dB, 3.94 dB, 4 dB, and 6.05 dB, respectively. The main beam directions in azimuth are obtained at -20°, 40°, -40°, and 20° for respective input port.

09:40 *Design of a Cavity-backed Slot Array Unit Cell on Inverted Microstrip Gap Waveguide*

Jinlin Liu and Abbas Vosooqh (Chalmers University of Technology, Sweden); Ashraf Zaman (University of Saskatchewan, Canada); Per-Simon Kildal (Chalmers University of Technology, Sweden)

Inverted microstrip gap waveguide is advantageous for millimeter wave application because of its low-loss, self- packaging characteristics and cost-effectiveness. In this work a planar gap waveguide slot array is presented. It is fed by a corporate distribution network realized in inverted microstrip gap waveguide. The structure consists of three layers. The top layer contains subarrays of 2 × 2 radiating slots. This is backed by an air-filled groove gap waveguide cavity. This cavity layer is fed by the inverted microstrip gap waveguide distribution network formed in the air-gap between the middle and bottom layer. The paper presents a design of the 2 × 2 subarray, i.e. the unit cell using simulations in an infinite array environment. The simulation results show that the S 11 is below -11 dB over 57-66 GHz frequency band covering 14% bandwidth, and the simulated directivity is about 39 dBi when evaluated for a 32 × 32 element slot array antenna.

10:00 *Beam-Steering Array for Handheld Devices Targeting 5G*

Alexandru Tatomirescu (Aalborg University, Denmark); Adriana Oprian (APNET, Denmark); Stanislav Stefanov Zhekov and Gert Pedersen (Aalborg University, Denmark)

In this paper, we present the array design for an implementation of a mobile terminal targeted for the fifth generation mobile communication network (5G). The design has a compact low loss array element printed on a low loss dielectric. To obtain a back lobe radiation, the ground plane is etched under the array elements and a parasitic scatterer is used to manipulate the gain pattern of the dipole in order to improve the peak gain. The array is placed on the top edge of the PCB in an 8 element array configuration. The design is evaluated using simulations and the simulated realized gain is 11.6 dBi at boresight, the array has a bandwidth of 1 GHz around 28 GHz with a good beam steering characteristics. About 80% of all the achievable angles for the incoming power distribution are covered with a gain better than 5 dB. Noteworthy is that a fine resolution of 15 degrees steps have been chosen.

S4.1: Small antennas I

Room: Wellington

Chairs: Karu Esselle (Macquarie University, Australia), Takafumi Fujimoto (Nagasaki University, Japan)

08:00 *Fabrication of F-Inverted Compact Antenna Using a 3D Printer*

Adrian Caldow and Laura Audino (Defence Science and Technology Organisation, Australia)

The fabrication of an electrically small 916 MHz F-Inverted Compact Antenna (FICA) suitable for use in Wireless Sensor Network (WSN) applications is reported. The design is constructed using a consumer quality 3D desktop printer to produce a dielectric former onto which a wire helical element is wound. The use of a printed former eliminates several variances that arise when the antenna is entirely constructed by hand, leading to a more repeatable and robust fabrication approach.

08:20 *A Simple Planar Monopole Antenna for Mobile Handset Applications*

Khaled Mahbub Morshed, Karu Esselle and Michael Heimlich (Macquarie University, Australia); Markus Dominik Mueck (Intel Mobile Communications, Germany); Stuart G Hay (CSIRO ICT Centre, Australia)

A printed monopole antenna with O-shaped ground plane presented in this paper covers FDD/TDD-LTE, DCS, PCS, and 2.4 GHz ISM bands for smartphone applications. The antenna has a wide impedance bandwidth of 2.02 GHz (1.12 - 3.14 GHz) with a voltage standing wave ratio of 3:1, given the overall antenna size is 40 mm x 15 mm x 0.035 mm. Peak gain of the proposed antenna is 5.30 dBi with a gain variation of less than 0.5 dBi in individual operating band. The total efficiency of the antenna is greater than 76% and less than 91%. Antenna's impedance bandwidth, gain, and total efficiency are assessed with and without a battery. Dimensions of the antenna are optimised for impedance bandwidth. Antenna radiation patterns in XZ and YZ planes for six different operating bands are presented with resonance frequencies 1.66, 1.76, 1.86, 1.95, 2.4, and 2.6 GHz.

08:40 *Injection Locking in Active Antenna*

Madhur D Upadhayay (Shiv Nadar University, India); Ananjan Basu (Indian Institute of Technology, Delhi, India); Mahesh Abegaonkar (IIT Delhi, India); Shiban K Koul (Indian Institute of Technology Delhi, India)

An oscillator type active antenna is designed using two-port microstrip antenna as feedback element for RF BJT amplifier. The injection locking of active antenna is demonstrated in time domain for first time. As per the reported literature active antenna circuit takes some time to lock at the frequency of injection signal. The locking time delay depends on injected power level and difference of active antenna free-running frequency and injected signal frequency. However it is observed experimentally for the first time that the dependency is weak, and only near the edge of the locking band does the locking delay rise sharply.

09:00 *A Novel UWB Dielectric Resonator Antenna with Dual Notched Bands*

Yinyan Chen and Yuehe Ge (Huaqiao University, P.R. China); Trevor S. Bird (Antengenuity & CSIRO, Australia)

A compact ultra-wideband (UWB) dielectric resonator antenna (DRA) with dual band-notched characteristics is proposed. A shorting conductor is attached to one side of the DRA, to reduce more than half the volume of the antenna. An inverted novel shaped strip is designed to print near the feed probe side, to achieve the dual band-notched characteristics. According to the simulated results, the antenna offers a VSWR<2 bandwidth of 2.9 GHz—11.0 GHz, with the dual notched bands of 5.15 GHz—5.825 GHz (WLAN) and 8.025 GHz—8.40 GHz (ITU), indicating that the antenna is a good candidate for various UWB applications.

09:20 *Circularly Polarized Small Microstrip Antenna for Wireless Sensor Network*
Takafumi Fujimoto, Takuma Tsuruoka, Tomoyuki Fujishima, Yoichi Ishizuka, Satoshi Sugimoto and Takuya Sasamura (Nagasaki University, Japan)
A circularly polarized square MSA with one pair of crank-shaped slit at each edge is proposed for wireless sensor network. The antenna has two frequencies giving the minimum axial ratio. The two frequencies are very close. In order to enhance the bandwidth of 3dB-the axial ratio, the two frequencies are tuned by the length of the crank-shaped slits. The simulated bandwidths of 3dB-axial ratio with 10dB-return loss is 2.398GHz-2.482GHz (3.5%). Moreover, the antenna radiates circularly polarized wave in wide angles. The size of the antenna patch is approximately (0.16 wavelength)^2. The designed antenna is small in size.

09:40 *Modelling the Effect of A Thin Shorting Post in an Arbitrary Position Along the Outer Radiating Edge of A Rectangular Patch Antenna*
Budhaditya Majumdar and Karu Esselle (Macquarie University, Australia)
An extended transmission-line model is proposed for a shorted rectangular patch antenna. The transmission-line model represents the effect of a thin shorting post placed at an arbitrary position along the outer radiating edge of the patch antenna. Comparative study has been conducted with a 3D full-wave solver. An example patch antenna having a resonance frequency of 2280 MHz without any shorting post, but can be re-tuned between 2375 MHz and 2511 MHz by varying the location of the shorting post. A special case with the post at one of the outer vertices is also considered. Maximum deviation between results obtained the extended transmission-line model and the full-wave solver is 0.74% for the example patch antenna.

10:00 *Electromagnetic Simulation of a Gold Nano-Cylinder Chain*
Shinichiro Ohnuki (Nihon University, Japan); Kazuya Nagasawa and Ryo Takahashi (Nihon university, Japan)
Recently, metal nano-particle chains are expected in a lot of practical applications such as light antennas, plasmonic waveguides, bio sensors, and so on. The chain can localize light energy in nano domain, because the energy can be transmitted as LSP (Localized Surface Plasmons). In this paper,the wavelength response of a gold nano-cylinder chain is investigated by using electromagnetic simulation. We discuss that the plasmonic resonant peaks can be tunable by varying the vibration direction of electrons and the distance between cylinders.

S5.1: Antennas for biomedical and healthcare applications

Room: Auditorium
Chairs: Koichi Ito (Chiba University, Japan), Stuart G Hay (CSIRO ICT Centre, Australia)

08:00 *Development of Hybrid Surgical Device Combining Microwave and Radio Frequency Current*
Sho Suzuki, Kazuyuki Saito and Koichi Ito (Chiba University, Japan)
Various types of surgical devices using microwave energy for the treatment of bleeding from the organs and blood vessels are investigated and reported. For smooth progress of the surgery, it is desirable that devices have functions of tissue coagulation and tissue resection. Generally, microwave energy is used for tissue coagulation and unsuitable for tissue resection because of the mild heating effect. Here, devices using joule heating due to radio frequency current are employed for tissue resections. In this study, a coagulation and cutting device with the microwave energy which has a good coagulation characteristic and radio frequency current which has a good dissection characteristic is proposed. In this paper, the heating characteristic of the designed microwave heating antenna loaded with the coagulation and cutting device was evaluated using finite-difference time-domain method and bioheat transfer equation. As a result, the designed antenna heats the grasped blood vessel more than 60 ºC around the heating antenna.

08:20 *Recent Developments in Antennas with Full Ground Planes for Wireless Body Area Networks*
Syed Muzahir Abbas, Yogesh Ranga and Karu Esselle (Macquarie University, Australia); Stuart G Hay (CSIRO ICT Centre, Australia)
This paper highlights recent developments in antennas with full ground planes, which have been designed for Wireless Body Area Networks (WBANs). These antennas are designed to provide single/dual band operation in 2.4GHz industrial, scientific and medical (ISM) band and 4.9GHz public safety wireless local area network (WLAN)/5GHz IEEE 802.11 WLAN bands. They have significant advantages of compactness, wide radiation pattern over the body surface, and less sensitivity to the variation of the gap between the antenna and the human body. These advantages make them suitable for on-body communications and wearable applications.

08:40 *Design of Implantable Antenna on the Dielectric/Ferrite Substrate for Wireless Biotelemetry*
Dong-Wook Seo and Jae-Ho Lee (Electronics and Telecommunication Research Institute (ETRI), Korea); Hyoungsu Lee (ETRI(Electronics and Telecommunications Research Institute), Korea)
A miniature and broadband implantable antenna is designed for wireless biotelemetry in the medical implantable communications service (MICS) frequency band (402 - 405 MHz). To minimize antenna size and enhance bandwidth, a meandered planar inverted-F antenna (PIFA) structure is adopted on a dielectric/ferrite substrate. The potential of the proposed antenna is verified through a prototype fabrication and measurement with 2/3 human muscle-emulating material environment. Good agreement is observed between the simulation and measurement in terms of resonant characteristics and gain radiation patterns of the antenna. The measurement shows broad bandwidth (return loss of 10 dB) of 226 MHz and maximum gain of -27.7 dBi at 403.5 MHz. Analysis of 1-g SAR distribution is conducted to satisfy the specific absorption rate limitation (1.6 W/ kg) of the American National Standards Institute.

09:00 ***Orthogonally Rotated Radiating Array for Improving Heating Uniformity in Hyperthermia System***

Woo Cheol Choi, Seonho Lim and Young Joong Yoon (Yonsei University, Korea)

An orthogonally rotated radiating array applicator is proposed to enhance the therapeutic suitability of superficial hyperthermia treatment system. The proposed applicator provides an optimal heating effect to widely distributed tumors by configuring the orthogonal arrangement of radiating elements. Each element causes a destructive interference of electromagnetic field at the center of the array applicator, so as to prevent an overheating at the central region. The electric field and the specific absorption rate (SAR) are evenly formed with a circular-shaped distribution, which allows for the uniform heat deposition on the therapeutic area. The achieved ETA ratio is 152.6 %, corresponding to 44 % increase, as compared with the single element operation. The proposed hyperthermia applicator not only leads to a wide therapeutic coverage by the orthogonally rotated array configuration, but it also satisfies the thermal requirement for tumor necrosis.

09:20 ***Challenges in the Localization of a UHF Radio Pill in the Gastro-Intestinal Tract***

Camille Aubry (University of Lorraine, France); Hugo G Espinosa and David V Thiel (Griffith University, Australia); Esmaeil S Nadimi (University of Southern Denmark, Denmark)

Visual and chemical investigations in the gastro-intestinal tract using injected "pill" sized sensors are challenging. The throughput takes between 24 and 48 hours and a precise location accuracy to less than 5 cm is necessary for keyhole surgery. Model and computational experiments using a 433 MHz subsurface transmitter in a saline (conductivity = 0.2 S/m) tank show that location accuracy is compromised by non-conducting boundaries between internal organs connected by non-conducting interstitial tissue. The internal transmitter profile changes significantly by the presence of insulating boundaries modelled by non-conducting boundary in an otherwise uniform conducting medium. A worn sensor array in the front of the abdomen can define the location of a GI pill only if there is significant information about the internal organ configuration.

09:40 ***Miniature Implantable PIFA for Telemetry in the ISM Band: Design and Link Budget Analysis***

Farhad Gozasht (University of Technology, Sydney & Sahand University of Technology, Australia); Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia)

An implantable miniaturized planar inverted-F antenna (PIFA) is proposed for biomedical applications. We present a small sized PIFA that can operate over 2.45 GHz Industrial, Scientific, and Medical (ISM) band which occupies a small volume of 92 mm3. The impedance characteristics of the proposed antennas are measured using experimental tissue mimicking phantoms. Results indicate the highly compact proposed PIFA with a size of 8.1×7.1×1.6 mm3 is suitable for implanting either in the chest or arm of human body. The proposed structure exhibit a decent performance when implanted under the skin or inside the muscle. The performance of the communication link between the implanted antenna and external dipole antenna is examined. A statistical pass loss analysis is also carried out. Moreover, the Specific Absorption Rate (SAR) distribution induced by the implantable antenna inside a human tissue phantom is evaluated.

10:00 ***A Compact Implantable Antenna for Bio-Telemetry***

Sumyea Sabrin, Karu Esselle and Khaled Mahbub Morshed (Macquarie University, Australia)

A compact implantable planar inverted-F antenna with the full ground plane is presented for bio-telemetry applications in the medical device radiocommunications service (MedRadio) band (401 - 406 MHz). A basic three layer phantom model of skin, fat and muscle is initially considered and the antenna is placed in the muscle layer. Later, Gustav voxel model is used to verify the design. The overall size of the antenna is 11.635 × 11.635 × 1.975 mm3, equivalent to 0.0156λ0 × 0.0156 λ0 × 0.00266 λ0 (here, λ0 is the free space wavelength at 403.5 MHz). The antenna has an impedance bandwidth of 2.73% (397.4 - 408.4 MHz) with a voltage standing wave ratio of 2:1 and peak realized gain of -29.6 dBi at 403 MHz. The estimated maximum SAR value of this antenna satisfies the IEEE and FCC standard safety guidelines for 1-g and 10-g average SAR at 403 MHz, allowing 3.37 mW and 27.05 mW maximum input power, respectively

10:40 - 11:30

S5.2.1: Keynote 1 - Antenna and Wireless Technologies for Safeguading Australia

Dr Alex Zelinsky - Chief Defence Scientist, Defence Science and Technology Organization (DSTO), Australia

Room: Auditorium

Chair: Y. Jay Guo (University of Technology, Sydney, Australia)

Antenna technology is critical for defence and national security. Chief Defence Scientist Dr Alex Zelinsky outlines cutting edge defence applications of smart antenna technology for surveillance, communications, electronic warfare and direction finding. The proliferation of broadband wireless communication technology poses new challenges that require antennas to adapt to changing operating conditions. DST Group has a long history of radar research and is continuing to find innovative applications in collaboration with international partners and Australian industry and universities. The presentation reflects on the traits of an ideal antenna and what's possible in the near future.

11:30 - 12:20

S5.2.2: Keynote 2 - Recent Medical Applications of Antennas

Prof Koichi Ito - Center for Frontier Medical Engineering, Chiba University, Japan

Room: Auditorium

Chair: Y. Jay Guo (University of Technology, Sydney, Australia)

In recent years, various types of medical and healthcare applications of antennas have widely been investigated and reported. Typical recent applications include:(1) Information / Wireless power transmission: - Wearable or Implantable vital data sensor / monitor - Wireless telemedicine / Mobile health system - Wireless capsule endoscopy(2) Diagnosis: - High intensity MRI (Magnetic Resonance Imaging) - Microwave CT (Computed Tomography) for cancer detection - Wireless sleep monitor / ECG (electrocardiogram) monitor(3) Treatment: - Thermal therapy (hyperthermia, ablation, etc) - Wireless brain stimulator - Surgical device (coagulation device, microwave knife, etc)In this presentation, some practical medical applications of antennas which have been studied in our laboratory are introduced. Firstly, a wearable dual-mode antenna for vital data monitoring systems is presented. A key technology for the antenna is body-centric wireless communications. Secondly, an X-band antenna for a microwave sleep monitor is demonstrated with human-body phantom experiments. A "dynamic" phantom played an important role for the study. Thirdly, after a brief description of thermal therapy and microwave heating, a coaxial-slot antenna and an array applicator composed of several coaxial-slot antennas for minimally invasive microwave thermal therapy are overviewed. A few results of actual clinical trials by use of coaxial-slot antennas are demonstrated from a technical point of view. Then, as a new therapeutic application of coaxial-slot antennas, intracavitary hyperthermia for bile duct carcinoma is briefly introduced. Finally, a few different types of surgical devices using high power microwave energy, including a new coagulation device which can detect the complete coagulation, are introduced. Heating characteristics of such microwave surgical devices are evaluated by numerical calculation as well as some experiments using phantoms, meat and animals.

13:00 - 15:20

S1.3: Metamaterials

Room: Tasman A

Chairs: Raj Mittra (Penn State University, USA), Hao Xin (University of Arizona, USA)

13:00 *Synthesizing Broadband Low-loss Artificially Engineered Materials (Aka Metamaterials) for Antenna Applications*

Ravi Kumar Arya and Shaileshachandra Pandey (The Pennsylvania State University, USA); Raj Mittra (University of Central Florida, USA and KAU, Saudi Arabia, USA)

Metamaterials (MTMs) were originally introduced as supplements to naturally found dielectric materials, with the promise that they would vastly enlarge the parameter range of natural materials and would thus provide a way to achieve exotic material properties such as double-negativity and zero-index characteristics that are not found in nature. What prompted a precipitous surge of interest in MTMs in the early days was their promise of achieving high-resolution lenses, high-gain antennas with only moderate-size apertures, and even small antennas with wide bandwidths. However, it was soon discovered by researchers in the field that while such properties were indeed achieved by MTMs, it was not without the cost of narrowing the bandwidths—sometimes severely—increasing the losses and lowering the antenna efficiency, also sometimes significantly. In this work, we discuss ways to mitigate these problems with MTMs, and discuss strategies for artificially synthesizing dielectric materials that are broadband and low-loss and, hence, are useful for real-world antenna applications.

13:20 *Metaspiral Antenna System*

Hisamatsu Nakano, Toshio Shimizu and Junji Yamauchi (Hosei University, Japan)

A metaspiral has a negative phase constant within a specific frequency band and a positive phase constant within a different frequency band. The circularly polarized (CP) beams radiated within these different bands have different gains. It is found that placing a dielectric plate above the metaspiral contributes to yielding a desirable situation where the gains for left-handed and right-handed CP waves are almost the same. It is also found that the input impedance is not deteriorated by the presence of the dielectric plate. The effects of removing the inner part of the dielectric plate on the antenna characteristics are also discussed.

13:40 *Metamaterial-Inspired Electrically Small Antennas Integrated Into Structural Materials*

Kelvin Nicholson (Defence Science and Technology Organisation, Australia); Thomas Baum and Kamran Ghorbani (RMIT University, Australia); Richard W. Ziolkowski (University of Arizona, USA)

An electrically small Egyptian axe dipole antenna has been designed and integrated into a glass fiber reinforced polymer (GFRP), a structural material now commonly found in most mobile platforms. The integration is accomplished by sewing the antenna with conductive threads into the GFRP prepreg and accounting for dimensional variations after curing under high temperature and pressure in an autoclave. The simulated and measured reflection coefficient values and radiated field patterns are in good agreement. These comparisons demonstrate that the antenna is nearly completely matched to the source without any matching circuit and radiates as an electric dipole.

14:00 *Improvement of Metasurface Continuity Conditions*

Karim Achouri and Mohamed A Salem (Polytechnique Montréal, Canada); Christophe Caloz (Ecole Polytechnique de Montreal, Canada)

We analyse the limitations of an ideal zero-thickness sheet model, based on electromagnetic susceptibility tensors, to synthesize a sub-wavelength thick metasurface. First, the ideal zero-thickness model is used to synthesize an absorbing metasurface in terms of its susceptibilities. Then, we show the discrepancies between the response of the zero-thickness metasurface and the response of a sub-wavelength thin slab possessing the same electromagnetic susceptibilities. Finally, we derive higher order continuity conditions to provide a more rigorous treatment of the problem of sub-wavelength thick metasurfaces.

14:20 *Anisotropic Reflective Metasurfaces for Manipulating Radiation Beams in Reflection*

Hui Feng Ma, Yan Qing Liu and Wenxuan Tang (Southeast University, P.R. China); Qiang Cheng (Southeast University, China, P.R. China); Tie Jun Cui (Southeast University, P.R. China)

We propose a kind of anisotropic metasurface, which is composed of orthogonal I-shaped structures and a grounded plane spaced by a dielectric substrate. The metasurface has capacity to manipulate the radiating characteristics of x- and y-polarized reflected waves independently by changing the dimensions of each I-shaped structure. By designing homogeneous anisotropic metasurface, the linear-polarized incident plane waves can be converted to circular polarized reflected waves in a broad frequency band. By designing inhomogeneous anisotropic metasurface, the x- and y-polarized incident plane waves can be separated and radiated to two different directions. Moreover, the anisotropic metasurfaces also have some applications in reflector antenna by using a horn antenna as a feed, and the incident quasi-spherical waves generated by the feed can be manipulated to plane waves after reflected by the metasurface, whose polarizations, directions and number of beams of the reflected plane waves also can be controlled as desired.

14:40 *Dynamically Controlling Electromagnetic Wave with Tunable Metasurfaces*

Yijun Feng, Bo Zhu, Ke Chen, Junming Zhao and Tian Jiang (Nanjing University, P.R. China)

Dynamic control of electromagnetic (EM) wave propagation (both the amplitude and phase) is essential to many practical applications. The recently developed two dimensional metamaterial - the metasurface, provides more convenient method to manipulate EM wave in a designable way within subwavelength distance. Here we incorporate electrical tunable elements into the metasurface designs to realize dynamic manipulation of EM wave propagation. We will show that the tunable metasurface inspired by the equivalent principle design can provide independent and dynamic tuning for the transmission magnitude and phase. Detailed theoretical analysis, simulation as well as experiment on prototype of tunable metasurfaces will be demonstrated. As an application example, we will also show our recent work on designing a planar Huygens lens that could achieve dynamic focusing through phase control of the metasurface.

15:00 *Active Metamaterials with Gain Compensation*

Hao Xin (University of Arizona, USA)

Despite attractive properties of metamaterials, many of the practical applications are limited by two fundamental issues that have not yet been solved, namely, loss and narrow bandwidth inherently associated with a typical passive metamaterial. In this talk, active metamaterial incorporating gain medium / device for loss compensation and wideband operation will be reviewed. Several examples including transmission line type and volumetric metamaterials with simultaneous negative index of refraction and gain will be presented. Important design considerations and applications will be discussed.

S2.3: Metamaterial and THz antenna research in Europe

Room: Tasman B

Chairs: Peter de Maagt (European Space Agency, The Netherlands), J (Yiannis) Vardaxoglou (Loughborough University, United Kingdom)

13:00 *Radiation From an Axial Electric Dipole with Oblate Spheroidal Metamaterial Cloak Cover*

Piergiorgio L.E. Uslenghi, Danilo Erricolo and Tadahiro Negishi (University of Illinois at Chicago, USA)

Exact analytical expressions for the electromagnetic field due to an electric dipole source located inside and along the axis of symmetry of an oblate spheroid are derived The spheroid is made of a penetrable, linear, isotropic, homogeneous and lossless material whose propagation constant is either equal (isorefractive cloak) or of opposite sign (anti-isorefractive metamaterial cloak) to the propagation constant of the medium surrounding the spheroid. In particular, the influence of the spheroid material on the radiation pattern is examined.

13:20 *Electrically Thin VHF Array Elements for Satellite Applications Using Artificial Magnetic Material*

Andrea Giacomini (Microwave Vision Italy (MVI), Italy); Luca Tancioni (MICROWAVE VISION ITALY, Italy); Francesco Saccardi (Microwave Vision Italy, Italy); Vincenzo Schirosi (MICROWAVE VISION ITALY, Italy); Lars Foged (Microwave Vision Italy, Italy); Andrea Di Cintio (CGS, Italy); Nelson Fonseca and Peter de Maagt (European Space Agency, The Netherlands); Jean-Marc Baracco (Mardel, France)

The application of large antenna arrays for space missions in VHF band is hindered by the dimension and weight of the single radiating element from a conventional design approach. Satellites used for this kind of applications are typically micro/mini platforms and cannot accommodate large antennas. To this purpose, element volume minimization and mass reduction are considered performance drivers, even considering the array deployment and satellite mass requirements. The important size reduction properties of Artificial Magnetic Materials (AMM) / Meta Materials (MM) made this approach a natural choice for the development of miniaturized antennas. A multipurpose, dual polarized array element with highly reduced dimensions and weight was developed to overcome these obstacles. This paper describe the design, manufacturing and testing of a dual polarized array element considering application in a low orbit Automatic Identification System (AIS) mission.

13:40 *Applications of Artificial Dielectric Layers for the Design of Planar Integrated Antennas*

Waqas Hassan Syed, Daniele Cavallo and Andrea Neto (Delft University of Technology, The Netherlands)

In this paper, we present an overview of our recent works on artificial dielectric layers (ADLs), used to enhance the radiation efficiency of planar printed antennas and arrays. The ADL is realized by introducing planar sub-resonant metallic inclusions in a host material. This allows to enhance the permittivity of the host medium, which is characterized by high anisotropy. An analytical method has been developed to model the ADLs, valid for arbitrary number of layers and generic illumination. After a general description of this method, two design examples are presented. The first utilizes a single ADL slab as a superstrate of an on-chip double slot antenna operating at 300 GHz. Simulated and measured results show an improvement of the antenna gain and overall efficiency of about 2 dB. The second example is connected-slot array loaded with an ADL superstate, to achieve wide-scan capability, up to 50 degrees in all azimuth planes, over an octave bandwidth.

14:00 *Dual Band THz-IR Detector for Radio-Astronomy Applications*

Ramon Gonzalo (Public University of Navarra, Spain); JuanCarlos Iriarte (Public University of Navarra & Antenna Group, Spain); David Etayo (Das-Nano & Das-Nano, Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain)

Dual band THz-IR receivers can be used in application within different fields. For instance, in radio-astronomy, dust emission in the infrared (IR) and submillimeter wave or THz ranges is used for star-formation characterization. This information is normally acquired by different detectors which operate at each of these frequencies; i.e. Terahertz and Infrared. The development of an integrated dual band detector operating at both frequency ranges will be described in this paper. The proposed configuration implements a spiral antenna working at sub-millimeter wave frequencies whose design is based on Fresnel zones theory. At the same time, this spiral antenna is used as Fresnel lens to focus IR power (12 μm) into an IR detector. Other applications such security can also benefit of this kind of systems.

14:20 *Leaky-Wave Antenna in Multilayer Structure for Sensor Applications*

Slawomir Gruszczynski, Artur Rydosz, Jakub Sorocki, Izabela Slomian, Piotr Kaminski and Krzysztof Wincza (AGH University of Science and Technology, Poland)

A leaky-wave antenna has been analyzed and designed for application in smart motion sensors. The application of multilayer structure with a thin laminate layer allows for manufacturing the required capacitive elements without the need for SMD components' application. The theoretical expressions are derived allowing for initial unit cell design. The designed antenna structure consisting of 30 unit cells has been designed and verified electromagnetically. Finally the model of the antenna has been manufactured and measured.

14:40 *Spatial Nonreciprocal and Nongyrotropic Structure*
Bakhtiar Khan (Ecole Polytechnique de Montreal, Canada); Shulabh Gupta (École Polytechnique de Montréal, Canada); Christophe Caloz (Ecole Polytechnique de Montreal, Canada)
A spatial nonreciprocal and a nongyrotropic structure has been proposed based on coupled resonators used in conjunction with a magnetless isolator, and has been demonstrated using full-wave simulations. Nonreciprocal spatial systems based on magnetic materials has the fundamental property of gyrotropy which is not always desired. The two coupled resonators were realized as co-polarized patch antennas coupled through an isolator, thereby exhibiting a strong non-reciprocity at the isolated resonant frequency of the patch antennas used.

S3.3: Millimeter wave and THz antennas

Room: Tasman C

Chairs: Zhang-Cheng Hao (SEU, P.R. China), Jiro Hirokawa (Tokyo Institute of Technology, Japan)

13:00 *Design of Non-uniform Aperture Illumination RLSA and Its Applications in mm-Waves*
Tung Nguyen, Jiro Hirokawa and Makoto Ando (Tokyo Institute of Technology, Japan)
This paper discusses a design of Radial Line Slot Antenna (RLSA) having non-uniform aperture illumination for specific applications in mm-wave band. We control the slot couplings to produce a linear taper amplitude distribution that can be applied into two cases: RLSAs having lossy dielectric waveguides and RLSAs for short-range communications. At 60GHz, several prototypes were designed and fabricated, and their measured taper amplitudes give better performances than the uniform designs, from the system point of view.

13:20 *Feasibility Study on a Slot Array in the Millimeter-Wave Band Based on a Conformal Waveguide*
Iwai Hiroshi (Panasonic Corporation, Japan); Satoshi Suetsugu, Jiro Hirokawa, Miao Zhang and Makoto Ando (Tokyo Institute of Technology, Japan)
In this paper, a slot array antenna based on a conformal antenna fed by a rectangular coaxial line to realize wide coverage over 120 degrees is proposed. In Section 2, it is confirmed that the angle, which the directivity gain of conformal antenna adopting a switching method with branch separation of 0.65λ is greater than that of a linear array, is 40 degrees. In Section 3, the simulated results of the 8x8-element array band indicate that the directivity gain was 15.7dBi at 79GHz.

13:40 *Cylindrical Conformal Array Antenna with Fan-shaped Beam for Millimeter-wave Application*
Kui Fan (Southeast University, P.R. China); Zhang-Cheng Hao (SEU, P.R. China)
A millimeter-wave cylindrical conformal array with 120o flat-top broad beam and a stable 30o downward tilted-angle is demonstrated, fabricated and measured in this paper. A 32-element longitudinal slots array antenna is selected as the radiating element of the cylindrical conformal array, which is wrapped around the cylindrical in the circumferential direction. A 1-to-8 unequal power divider and a compact phase compensating network are developed for the designed 8x32 slot array. Measured results show that a 120o flat-top broad beam with stable 30o downward angle is achieved over the operating frequency band. The proposed new conformal array antenna can be used in millimeter wave base station system.

14:00 *Analysis of Intersymbol Interference in a 60 GHz-Band Compact-Range Wireless Access System Using Various Large Array Antennas*
Miao Zhang, Masahiro Wakasa, Kiyomichi Araki, Jiro Hirokawa and Makoto Ando (Tokyo Institute of Technology, Japan)
A compact-range wireless access system in the 60 GHz-band has been proposed for multi-Gb/s data transfer. Large array antennas adopting in the transmitter operate in their near-field regions, and provide us with a large communication zone and a pure propagation environment. However, intersymbol interference (ISI) may significantly degrade the system performance especially when the receiver is close the transmitter due to the large transmitting antenna size. In this paper, the corporate feed waveguide slot array with square aperture and the radial line slot array with circular aperture are investigated. The concept of ISI is essential to improve the overall system performance.

14:20 *Software-defined Reconfigurable Antenna Using Slotted Substrate Integrated Waveguide for Ka-band Satellite-on-the-Move Communication*
Yifan Wang (University of Queensland, Australia); Amin Abbosh (The University of Queensland, Australia)
A software-defined pattern reconfigurable Ka-band antenna for high-speed satellite-on-the-move (SOTM) application is presented. The proposed antenna employs the concept of travelling-wave slotted integrated waveguide to achieve a high-directivity radiation beam as needed for satellite communications. The substrate integrated waveguide (SIW) is employed as the antenna's main structure to lower the antenna's cost and weight. To realize the radiation-pattern configurability at a certain frequency, hundreds of computer-controlled PIN diodes are installed on the top slotted layer of the SIW structure to control the effective distance between the slots. The design parameters of the antenna are calculated using the leaky-wave space harmonic theory and further verified by full-wave simulations. As a proof of concept, a linear array with total length of 20cm×1cm is designed and simulated. Up to ±20° steering range of the main beam can be achieved with 15dBi gain. In a planar structure of dimensions 20cm×20cm, the gain is increased to 22dBi gain at 20 GHz.

14:40 *An E-band Circularly Polarized Antenna Array Fed by Substrate Integrated Coaxial Line (SICL)*

Li Cheng and Hong Wei (Southeast University, P.R. China); Zhang-Cheng Hao (SEU, P.R. China)

A circularly polarized antenna array for E-band application has been designed, fabricated and measured. The antenna array is fed using substrate integrated coaxial line (SICL) technology, which can be realized by low-cost PCB process in millimeter frequencies. The simulated and measured S11 is below -10dB from 71GHz to 76 GHz. And the simulated and measured results show that both the gain ofmore than 11dBi and axial ratio of less than 2dB have been achieved over the interested frequency band.

15:00 *Metamaterial Antenna Integrated to LiNbO3 Optical Modulator for Millimeter-Wave-Photonic Links*

Yusuf Nur Wijayanto (National Institute of Information and Communication Technology & Indonesian Institute of Sciences, Japan); Atsushi Kanno (National Institute of Information and Communications Technology, Japan); Ashif Aminulloh Fathnan (Indonesian Institute of Science, Indonesia); Pamungkas Daud (Indonesian Institute of Sciences, Indonesia); Tetsuya Kawanishi (National Institute of Information and Communications Technology, Japan); Dadin Mahmudin (Indonesian Institute of Sciences (LIPI), Indonesia); Naokatsu Yamamoto (National Institute of Information and Communications Technology, Japan)

We report current research progress on a metamaterial antenna integrated to an optical modulator for millimeter-wave-photonic links. The metamaterial antennas are composed by an array of electric-LC resonators on a LiNbO3 optical crystal. Large electric field is induced across the capacitance gaps of the resonators due to free-space millimeter-wave irradiation. Optical modulation through Pockels effects can be obtained when light propagates along the capacitance gaps. The integrated device is operated effectively by considering transit-time between millimeter-wave and lightwave electric fields along the capacitance gaps. Basic operations of the integrated device for 90GHz millimeter-wave bands are reported and discussed. Optical sidebands with carrier-to-sideband ratio of about -50dB by millimeter-wave irradiation power of ~20mW can be experimentally measured using optical spectrum analyzer.

S4.3: Microwave techniques for medical diagnostic and therapeutic applications I

Room: Wellington

Chairs: Amin Abbosh (The University of Queensland, Australia), Sergey Kharkovsky (University of Western Sydney & UWS, Australia)

13:00 *Recent Advances in Designing Balun-Free Interstitial Antennas for Minimally-Invasive Microwave Ablation*

Hung Luyen (University of Wisconsin-Madison, USA); Yahya Mohtashami, James Sawicki and Jacob Shea (University of Wisconsin Madison, USA); Susan C. Hagness (University of Wisconsin, Madison, USA); Nader Behdad (University of Wisconsin-Madison, USA)

We discuss recent advances in the design of balun-free interstitial antennas for minimally-invasive microwave ablation. The first class of antennas consists of monopole-type radiators fed at their bases using coaxial cables and operated at the second resonant frequency. Under these conditions, a compact specific absorption rate pattern is achieved without the need to use a coaxial balun. The second class of antennas consists of balanced dipole or loop antennas fed with inherently balanced, shielded transmission lines. In such a structure, the current flowing on one conductor of the feeding line is balanced by the current flowing on the other conductor. Therefore, no RF current flows on the outer surface of the floating shield and the antenna achieves a compact SAR pattern and localized heating zone. Design considerations, principles of operation, and measurement results including the results of ex vivo ablation experiments for representative prototypes of both classes of antennas are presented and discussed.

13:20 *Wavelet-Based Compressive Sensing for Head Imaging*

Lei Guo and Amin Abbosh (The University of Queensland, Australia)

A wavelet based compressive sensing technique for head imaging is presented. The non-sparsity of the dielectric profile of the human head brings about difficulties when applying traditional compressive sensing technique to image the profile of the head. In this paper, the wavelet transform is implemented to convert the non-sparse profile into a sparse domain then a compressive sensing framework named block sparse Bayesian learning (BSBL) is applied on the Born iterative method (BIM) model to reconstruct the original profile of the non-sparse domain. The proposed method is evaluated on a realistic human head phantom. The results show that a very low normalized error rate at a short computation time using small number of antennas can be achieved. The obtained results indicate that the presented technique can enable detecting an early stroke in the realistic non-sparse environment of the human head using only six antennas.

13:40 *Frequency Domain Artifact Removal Technique for Multistatic Microwave Head Imaging*

Ali Zamani and Amin Abbosh (The University of Queensland, Australia)

Microwave techniques have the potential to be used for head imaging to detect brain abnormalities. However, the outer section of the human head, which consists of different tissue layers, such as skin, skull, fat and muscles, presents a strong signal reflections and scattering clutter that might mask the target's response. In addition, those reflections tend to persist over a long duration of time, due to the multilayer structure of the head. These artifacts debilitate microwave imaging algorithms to successfully detect brain injuries inside the head. In this paper, a hybrid artifact removal method which combines the entropy-based filtering and differential approach, is presented to remove those artifacts in multistatic microwave head imaging. In this method, an entropy-based filter separates strong reflections from other signals, whereas the differential approach removes the artifacts from those reflections at different frequency samples. The proposed approach is successfully tested using realistic multilayer head model and an 8-element antenna array.

14:00 *Feeding Network for Microwave Hyperthermia Treatment of Brain Tumor Using Wideband In-Phase Power Divider*

Ummee Ahmed, Beada'a Mohammed and Amin Abbosh (The University of Queensland, Australia)

An in-phase power divider as a feeding network for two-element antenna array for microwave hyperthermia treatment of brain tumor is presented. The proposed power divider is used for the simultaneous power distribution between two element antenna array, where equal amplitude and in-phase signals are required. It is designed using two pairs of coupled lines to achieve 100% fractional bandwidth. The antenna array is designed using corrugated tapered slot antennas to cover more than 100% fractional bandwidth. The whole structure is optimized using CST MWS. The performance of the power divider and the antenna array is analyzed by means of simulations across the band 1-3 GHz, which is used in most if not all microwave hyperthermia applications. To be able to control the direction of the array's mainbeam, a phase shifter is included in feeding line of one of the antenna elements. The whole structure is tested on a realistic head phantom to investigate the penetration of fields inside head.

14:20 *Microwave Coaxial Antenna for Cancer Treatment: Reducing the Backward Heating Using a Double Choke*

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

In this paper, we focus on the so-called backward heating problem, which appears when coaxial-type antennas are used to treat certain types of cancers. The aim of this study is to reduce the surface currents propagating along the outer conductor of the antenna that lead to a higher Specific Absorption Rate (SAR) and overheat the healthy tissues. Our study shows that the use of a double-choke can lead to a lower SAR compared to the case of a single one. We also demonstrate that the use of a periodic structure does not help to further improve the SAR-level along the antenna.

14:40 *Review of Systems for the Detection and Monitoring of Accumulated Fluids in the Human Torso*

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

A fluid buildup in the torso, such as inside the lungs (pulmonary edema) or around the lungs (pleural effusion), is among the common symptoms of various diseases such as cancers, and heart and liver failures. The chest X-ray and computer tomography (CT)-scan are the most widely used non-invasive devices for the detection of the accumulated fluid. Due to the high cost and ionizing radiation of the aforementioned diagnostic tools, there has been huge research efforts to design alternative tools that are non-invasive, efficient, low-cost and safe for long term monitoring. This paper presents a brief review of the recently proposed systems for the detection of torso fluid accumulation using different modalities. This review indicates that microwave-based imaging systems are the most promising technique as a diagnostic tool of this serious medical condition.

15:00 *A Microwave Technique with an Implantable Open Cylindrical-Rectangular Antenna for Therapeutic Biomedical Applications*

Robert Salama (Western Sydney University, Australia); Sergey Kharkovsky (University of Western Sydney & UWS, Australia)

In this paper, a 2.45-GHz microwave wireless power transmission technique with an implantable open cylindrical antenna, a rectifying circuit and an external antenna module is designed and characterized for biomedical applications. The geometry of the open cylindrical antenna facilitates its direct installation in human tissue for therapeutic applications such as nerve stimulation. The simulation results show that the implanted open cylindrical antenna has an acceptable performance in human tissue and that the microwave wireless power transmission technique with this antenna is capable of delivering an electrical stimulus that can be used for nerve stimulation while maintaining a specific absorption rate that conforms to the IEEE standards.

S5.3: Reconfigurable antennas I

Room: Auditorium

Chairs: Hiroyuki Arai (Yokohama National University, Japan), Jacob Coetzee (Queensland University of Technology, Australia)

13:00 *2D Beam Scanned Optical Leaky Waveguide Antenna*

Hiroyuki Arai (Yokohama National University, Japan)

This paper proposes an optical beam scanning antenna consisting of switched beam waveguide and leaky waveguide. Azimuth angle is changed by switching propagating direction inside waveguide and elevation scanning is given by sweeping the wavelength of tunable laser from 1500 to 1600 nm. The proposed antenna geometry is described in detail and wide angle beam scanning method in elevation plane is presented by introducing optical switches. A waffled leaky waveguide is designed and fabricated by silicon photonics process and its beam scanning is also demonstrated.

13:20 *Voltage Beam-Steerable Leaky-wave Antenna Using Magnet-less Non-Reciprocal Metamaterial (MNM)*

Yuhi Yokohama and Toshiro Kodera (Meisei University, Japan)

A novel voltage beam-scanning leaky-wave antenna, consisting of an array of traveling-wave resonant particle by metal ring resonator with variable capacitance and unilateral component is proposed, analyzed, and measured. In contrast to ferrite-based leaky-wave antenna, this antenna does not require a biasing magnet but only an bias voltage for the FETs, and beam steering voltage for varactor diodes. The simulation result exhibits clear full-space beam scanning at 7 GHz, and its properties are examined by prototype antenna structure.

13:40 *On the Tuning Range of a Reconfigurable Half-Mode Substrate-Integrated Cavity Antenna*

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

In this paper the theoretical maximum tuning range of a frequency-reconfigurable antenna based on a half-mode substrate-integrated cavity is investigated and discussed. The antenna, which has recently been proposed by the authors, demonstrated a measured frequency tuning range of about 42% based on the capacitance range offered by practically available varactors. In the present investigation, the capacitance range is assumed to be unlimited, i.e. varying from 0 to infinity; then the tuning range is analytically calculated for different structure dimensions. It is shown that theoretical upper limit for the tuning range of this antenna is about 80% when the loading stubs' length is equal to the half guided-wavelength at the maximum frequency of operation. This investigation provides guidelines on the stub sized to be used in the design of stub-loaded reconfigurable antennas to achieve a maximum continuous tuning range.

14:00 *Switchable-Feed Reconfigurable Ultra-Wide Band Planar Antenna*

Soumya Sheel and Jacob Coetzee (Queensland University of Technology, Australia)

Reconfigurable antennas capable of radiating in only specific desired directions increase system functionality in applications like direction finding and beam steering. This paper presents the design simulation, fabrication and measurement of a horizontally polarized, direction reconfigurable Vivaldi antenna, designed for the lower-band UWB (2-6 GHz). This design employs eight circularly placed independent Vivaldi antennas with a common port, electronically controlled by PIN diodes acting as RF switches. Experimental results show that the reconfigurable antenna has a bandwidth of 4 GHz (2-6 GHz), with 5 dB gain in the desired direction and capable of steering over the 360° range.

14:20 *Direction Controlled Planar Reconfigurable Antenna Using Flared Radiators*

Md. Shahidul Alam and Amin Abbosh (The University of Queensland, Australia)

A direction controlled reconfigurable antenna that has four switchable operating modes is presented. The direction of the main radiation beam can be changed from 0° to 180° at 45° angular steps in the azimuth plane. The proposed antenna consists of two flared radiators, truncated ground plane and two parallel strips near its edges. It is controlled using four PIN diodes. The antenna operates across the frequency range 1.93-2.74 GHz to support Bluetooth, WiMax, WLAN and many other wireless services. The antenna has narrow radiation beams in the azimuth planes for reasonable selectivity and wide beams in the elevation plane for wide coverage. The designed antenna has a peak gain of 3.5 dBi and average gain of more than 2 dBi over the covered band. Despite using a simple structure and controlling mechanism, the antenna represents a suitable candidate compared to other antenna designs operating at the same frequency band. It has a compact dimension of 38×48×1.6 mm3 using FR4 substrate.

14:40 *Frequency and Polarization Reconfigurable Antenna for Airborne Application*

Sachin Jain and Sivarami Reddy (DRDO, India); Pummy Ratna (Defence Research & Development Organization, India); Usha P Verma (DRDO, India)

Reducing weight and improving stealth capacity of onboard airborne system is always been a desirable feature. Reduction in number of antennas mounted onboard for communicating with ground system improves both the values of the system. This paper proposes a new design to replace the presently used three antennas working at different frequencies (two at S band, one at C band) and polarization by a frequency and polarization reconfigurable antenna. The microstrip patch antenna is designed and optimized in such a way that interconnection between patches tuned antenna from higher to lower frequency. Three coaxial feed points are provided for three operational frequencies. Polarization reconfigurability from circular to linear is achieved through positioning of these feed points and interconnection via switching.The Comparison of simulation and measurement result is presented. The measured return loss is better than 12 dB at three resonant frequencies and axial ratio is 3 dB, which meets the operational requirements.

15:40 - 18:00

S1.4: Multi-band and wide-band antennas II

Room: Tasman A

Chairs: Ying Liu (Xidian University, P.R. China), Jiaran Qi (Harbin Institute of Technology, P.R. China)

15:40 *Experimental Study on Load Resistance Design of a Differential Rectenna*

Jun Takahashi, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

In this paper, a new design concept of rectennas' load resistance is proposed and the feasibility is experimentally studied. The RF-DC conversion efficiency of rectennas depends on its load resistance. The load resistance characteristic of rectenna can be adjusted by changing the impedance matching between antennas and a rectifying diode. Three prototype differential rectennas designed for different load resistance are experimentally evaluated. It is found to be feasible to design the optimum load resistance using matching shorted stubs without harming RF-to-DC conversion performance.

16:00 *Design of Tapered Slot Antenna Divided Into Some Parts*

Kuniaki Suto (Saitama Institute of Technology Graduate School, Japan); Akinori Matsui (Saitama Institute of Technology, Japan)

This paper proposes a design method for a tapered slot antenna divided into parts. Previous reports have discussed the matching characteristics obtained by the S-parameter method related to the measurement of the input impedance. In these reports, the measured and simulated input impedances were shown to differ in the high frequency region. This article shows that better agreement can be achieved by the appropriate compensation of the feed reference. Moreover, a design parameter for the taper is introduced when a high gain and low sidelobe level are obtained.

16:20 *Compact UWB Dielectric Resonator Antenna with WLAN Band Rejection*
Mohammad Abedian (Universiti Teknologi Malaysia (UTM) & Wireless Communication Centre, Malaysia); Sharul Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia); Shadi Danesh (Wireless Communication Centre, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Malaysia); Tharek Abdul Rahman (Wireless Communication Centre, Malaysia)
A new compact band-notched dielectric resonator antenna (DRA) for ultra-wideband (UWB) applications is presented. The antenna element consists of a thin monopole printed antenna loaded with rectangular dielectric resonator (RDR) which is housed into a dielectric substrate, a slot on the ground plane, and an I-shaped parasitic strip. Here, to realize band-notched characteristic, an I-shaped parasitic strip is placed on the DRA. By cutting slot on the ground plane, impedance matching performance is improved. The proposed antenna provides satisfactory UWB performances, with an impedance bandwidth of around 98 % excluding a rejection band for WLAN, excellent Omni-directional radiation patterns, nearly constant gain, and high radiation efficiency across the whole desired frequency band.

16:40 *Design of Sector Antenna with Wideband 2D Hat-fed Reflector for Wireless Communications*
Zhixing Chen, Jian Yang and Per-Simon Kildal (Chalmers University of Technology, Sweden)
We present the design of a new sector reflector antenna with 2-dimensional hat feed in order to avoid the radio link disconnection in point-to-point link communication systems due to the swinging of link antennas when there is a strong wind or vibration. The antenna has a 32% bandwidth for both the reflection coefficient below -17.8dB and the sidelobes of the radiation pattern in vertical plane below ETSI Class 3 envelope,based on the simulated results.

17:00 *A Triple-Band Compact Antenna Based on CSRR and LHTL*
Jiaran Qi, Chang Liu and Shanshan Xiao (Harbin Institute of Technology, P.R. China)
A triple-band compact antenna fed by coplanar waveguide (CPW) suitable for indoor communication is presented in this paper. The proposed structure is the combination of a complementary split-ring resonator (CSRR) and a left-handed transmission line (LHTL). The CSRR, working in quarter-wave monopole mode, contributes the first two operating frequency bands, which are further broadened by an additional triangular transitional structure. The LHTL implemented by interdigital capacitors and ground poles provides the third frequency band operating in a resonant mode. Detailed simulation results are presented to confirm our idea and design procedure.

17:20 *Evaluation of Two- To Eight-element Antenna Array in Mobile Terminal*
Azremi Abdullah Al-Hadi (University Malaysia Perlis, Malaysia); Mohamad Kamal A. Rahim and Noor Asmawati Samsuri (Universiti Teknologi Malaysia, Malaysia)
An extensive evaluation of practical 3400-3600 MHz multi-element mobile antennas (MAs) have been performed in indoor propagation environments. The overall performances are assessed by means of average efficiency and Multiple-Input Multiple-Output (MIMO) capacity. The study covers both uniform and actual multipath environments with consideration of user's interaction. The number of antenna elements is varied from two to eight to analyze the impact of the number of antenna elements on the foregoing performance metrics. While in an uniform environment the maximum MIMO channel capacity is obtained with the eight-element antenna array, measurements in real scenarios show that the maximum MIMO channel capacity is in practice obtained with a lower number of elements.

17:40 *Wideband Decoupling Network for Antenna Coupling with Large Group Delay*
Hidetoshi Makimura, Kengo Nishimoto, Takashi Yanagi, Toru Fukasawa and Hiroaki Miyashita (Mitsubishi Electric Corporation, Japan)
This paper presents a novel wideband decoupling network for frequency-dependent antenna coupling. The network consists of directional couplers, a transmission line, and a parallel resonant circuit. The network cancels the mutual coupling by the superposition of a designed coupling that has the same magnitude and opposite phase as the original one. Further, the proposed approach accommodates the variation in the coupling magnitude and the large group delay in the coupling phase. Therefore, it is easy to apply the approach to wideband applications. The design formulas are also derived for it. With these formulas, the resultant coupling with the proposed technique is 22.9 dB smaller than the original one at 3.5% bandwidth with a large group delay.

S2.4: Wireless power transmission and energy harvesting

Room: Tasman B

Chairs: Tharek Abdul Rahman (Wireless Communication Centre, Malaysia), Jung Ick Moon (Electronics and Telecommunications Research Institute, Korea)

15:40 *Oval Double Spiral Coil for High Wireless Power Transmission Efficiency*
Shun Hasegawa and Hisao Iwasaki (Shibaura Institute of Technology, Japan)
In this paper, we attempt to obtain high wireless power transmitting efficiency which does not depend on the position offset and the angle change between the transmitting coil and the receiving coil. For this purpose, we propose the oval double spiral coil. At first, the wireless power transmitting efficiency by angle change between the transmitting coil and the receiving coil is simulated. Second, the wireless power transmitting efficiency is simulated when the receiving coil is offset relative to the transmitting coil. And we propose the method to increase wireless power transmitting efficiency. Most efficient method is minor axis angle rotation of the receiving oval double spiral coil and offset the receiving oval double spiral coil relative to the transmitting coil.

16:00 *Study on the Effective Loading Pattern of Magnetic Sheet for Receiving Coil in WPT System*
Naoki Ohmura (Microwaveabsorbers inc., Japan); Takaho Sekiguchi and Yoshinobu Okano (Tokyo City University, Japan)
Wireless Power Transfer (WPT) system in accordance with Qi standard is being installed in smart phone in recent years. But the transmission efficiency is greatly deteriorated due to nearby metallic objects. To solve this problem, magnetic sheet with high permeability is set between WPT coil and nearby metallic objects. In order to make thickness of these materials thinner, we propose amorphous magnetic sheet. Besides this amorphous magnetic sheet causes to increase the transmission efficiency.

16:20 *Long Range and Safe Wireless Power Transmission with Matched Rectifier*
Brock DeLong (The Ohio State University & ElectroScience Laboratory, USA); Qiaowei Yuan (National Institute of Technology, Sendai College, Japan); John L. Volakis (Ohio State University, USA)
A long range wireless power system operating at 2.45 GHz is developed. The system is comprised of: 1) high gain horn antennas, 2) iteratively tuned matching/filtering network, 3) high efficiency rectifier, and 4) optimized load. An iterative technique is then used to match the antenna to the rectifier to greatly improve the efficiency. The rectifier is built around a single shunt diode rectifier topology. The output of the rectifier is fed to an optimized load, producing efficiency above 45% at 0 dBm. The overall system is able to operate across half a meter wirelessly.

16:40 *Semi-Elliptical Dipole Antenna for RF Energy Scavenging*
Kashka Irani (Royal Melbourne Institute of Technology University, Australia); James Scott and Kamran Ghorbani (RMIT University, Australia)
A method to miniaturize a planar semi-elliptical dipole antenna in the FM band (88-108 MHz), is presented. The proposed method modifies the antenna's structure, having dimensions of a roof tile (L = 432 mm x W = 345 mm), so that an array can be created. The first step was to use slots to meander the surface current path of the antenna lowering the resonating frequency and size. The second step involved using a passive matching network to further reduce the overall dimensions of the antenna with minimal loss. It was shown by using both slots and a matching circuit a size reduction of 0.31λ x 0.25λ was achieved with a bandwidth of 6% and a gain of 0 dBi at 100 MHz. This antenna can be used for RF energy scavenging applications.

17:00 *Compact Filtenna with Defected Ground Structure for Wireless Power Transfer Application*
Mursyidul idzam Sabran, Sharul Kamal A. Rahim and Chee Yen (Bruce) Leow (Universiti Teknologi Malaysia, Malaysia); Tharek Abdul Rahman (Wireless Communication Centre, Malaysia); Akaa A Eteng (Universiti Teknologi Malaysia, Malaysia); Noorlindawaty Md Jizat (Universiti Teknologi Malaysia Skudai & Multimedia University, Malaysia)
A compact proximity coupled high harmonic rejection filtenna is presented in this paper. The proposed structure operates in the unlicensed 2.45GHz Industrial, Scientific and Medical (ISM) band. A circular ring slot has been built-in on the ground plane parallel to circular patch, resulting in a 45% reduction area of patch element area as compared to conventional designs. Unique U-shaped slot arrangements are created on the ground plane parallel to the transmission line feed as defected ground structures (DGS) to achieve rejection of higher harmonics. Acceptable suppression of the second and third harmonics is achieved with minimum reflection coefficients of -4.1 dB and -1.8 dB respectively. The proposed design shows good potential for implementation in wireless power transfer and radio frequency energy harvesting infrastructure.

17:20 *Selective Wireless Power Transfer Using Two Transmission Coils Sandwiching Reception Coils*
Akira Yoshida, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)
In this paper, a selective wireless power transfer system using two transmission coils is proposed. In this system, a magnetic resonant coupling between two transmission coils and two reception coils aligned on a line is used. By applying the phase difference to the two transmission coils, the power transferred to the two reception coils can be controlled. The mechanism of the proposed system is described using an equivalent circuit and the feasibility of the system is experimentally demonstrated. The maximum power transfer efficiency of 69% is obtained at the phase difference of 90 degrees where the power transfer to another reception coil is 10%.

17:40 *Simplified Near-Magnetic Field of the Resonators in Wireless Power Transfer*
Jung Ick Moon (Electronics and Telecommunications Research Institute, Korea)
This paper presents the simplified modeling of near-magnetic field using equivalent magnetic dipole in wireless power transfer. In modeling of magnetic resonators, it is practice to ignore the volume of the resonator in comparison with the wavelength and consider it into the magnetic dipole on the ground plane. And the analysis presented here leads to reasonable modeling and analyzed results compare well with full-wave simulation. The utility of this approach is useful for the case when the human safety with respect to electromagnetic fields (EMFs) and interference problems should be considered in the design of wireless power transfer system.

S3.4: Antenna arrays II

Room: Tasman C

Chairs: Kumarasamy Somasundaram Senthilkumar (PNG University of Technology, Papua New Guinea), Krzysztof Wincza (AGH University of Science and Technology, Poland)

15:40 *Relay Multiplexing Enhancement Using a Nonreciprocal Antenna Array*
Rui Zang (University of Electronic Science and Technology of China, P.R. China); Christophe Caloz (Ecole Polytechnique de Montreal, Canada); Qingfeng Zhang (South University of Science and Technology of China, P.R. China)
We introduce the concept of a nonreciprocal relay for multi-user communication in a cluttered environment. This relay is based on a nonreciprocal antenna array system that receives and transmits in different directions of space according to uplink and downlink requirements. This relay features much higher gain than its conventional reciprocal and omnidirectional counterpart, where power is lost in undesired directions due to reciprocity. The proposed relay is demonstrated using in three-user system design so as to receive and transmit uniquely in the appropriate directions for both uplink and downlink.

16:00 *A Parallel Plate Slot-Pair Array Dual Polarization Antenna for Small Satellite SAR*
Vinay Ravindra (University of Tokyo, Japan); Prilando Akbar (Institute of Space and Astronautical Science/ Japan Aerospace Exploration Agency, Japan); Hirofumi Saito (Institute of Space & Astronuatical Science Japan, Japan); Miao Zhang and Jiro Hirokawa (Tokyo Institute of Technology, Japan)
A parallel plate slot-pair array antenna panel with dual circular polarization for application in space-based Synthetic Aperture Radar has been designed and fabricated. Multi-objective genetic algorithm is used to find an optimal set of slot-pair linear array power coupling coefficients. HFSS software is used to simulate the structure. The fabricated antenna panel shows aperture efficiency of 53.7% and 53.1% at 9.65 GHz for RHCP and LHCP beams respectively. Frequency dependency of the gain, and respective beam-shift between RHCP, LHCP beams are studied.

16:20 *A Simple Single-Feed Array of Uniform Half-Width Microstrip Leaky-Wave Antennas for Boresight Radiation*
Debabrata Kumar Karmokar and Karu Esselle (Macquarie University, Australia); Stuart G Hay (CSIRO ICT Centre, Australia); Trevor S. Bird (Antengenuity & CSIRO, Australia); Michael Heimlich (Macquarie University, Australia)
A simple leaky-wave antenna (LWA) array is presented here radiates in the boresight direction. It is based on uniform half-width (HW) microstrip leaky-wave antennas (MLWAs). Uniform HW-MLWAs usually radiate a fan-shaped beam with a beam direction near boresight at lower frequencies and near endfire at higher frequencies. One of the main challenges of uniform LWAs is to make them radiate toward the boresight. Six uniform HW-MLWAs are used in this array to overcome this limitation. The whole array is on a single substrate and is fed at the centre by a single probe. The peak gain of the array is 10.9 dBi and its 3dB gain bandwidth for boresight radiation is 270 MHz.

16:40 *A Linearly Polarized Radial Line Dielectric Resonator Antenna Array*
Lin Yuan (Beijing University of Posts and Telecommunications, P.R. China); Ming Su (Being University of Post and Teleommunication, P.R. China); Yuanan Liu (Beijing University of Posts and Telecom, P.R. China); Shulan Li (Beijing University of Posts and Telecommunications, P.R. China); Xiaoyan Miao (Beijing Institute Information and Control, P.R. China)
We propose a linearly polarized dielectric resonator antenna (DRA) array, feeding by radial line waveguide, to simplify the traditional feeding structures of the DRA array. By effectively using the electromagnetic wave inside the radial line waveguide, the proposed dielectric resonator antenna array, with only one feeding port, working at 12GHz, achieves a directivity of 27.18 dB, a high aperture efficiency of 66.4%, a total efficiency of 62.95% and good linearly polarization properties.

17:00 *Integrated Feeding Network for Excitation of Dual-Linear Polarization in Series-Fed Antenna Lattice*
Krzysztof Wincza, Izabela Slomian, Artur Rydosz and Slawomir Gruszczynski (AGH University of Science and Technology, Poland)
A concept of integrated feeding network designated for excitation of dual-linear polarization in series-fed microstrip antenna lattice has been proposed. The presented feeding network is composed of two Wilkinson power dividers and two 3-dB/90° directional couplers acting as a transmission-line crossover. As it has been shown such a compact network can be easily integrated with the recently developed antenna lattice, and therefore, allows for reduction of dissipation losses in the feeding network. The proposed concept has been experimentally verified by the design of an antenna lattice operating in 5.4 GHz frequency range.

17:20 *A Single Beam Smart Antenna for Underground Mine Communications*
Herman Kunsei (Papua New Guinea University of Technology, Australia); Kandasamy Pirapaharan, Kumarasamy Somasundaram Senthilkumar and Paul Hoole (Papua New Guinea University of Technology, Papua New Guinea)
Multipath reflections, rugged surfaces of the tunnels, and communication through multiple tunnels with irregular surfaces are amongst the critical challenges to using wireless underground communications systems. One major need is to cut down on the beams, except the main lobe, while steering the beam towards the desired transceiver so as to avoid generating multipath rays and to be effective in minimizing battery power. In this paper we present an analysis of array antenna that forms a single beam without the need for reflectors or complex arrangement of the array elements. It can be shown that dipole elements placed in a straight line is not effective in minimizing battery power and minimum 3 elements are sufficient for forming a single directed beam rotatable to all directions electronically. We have compared 3,4 and 6 elements for the accuracy.

S4.4: Microwave techniques for medical diagnostic and therapeutic applications II

Room: Wellington

Chairs: Amin Abbosh (The University of Queensland, Australia), Sergey Kharkovsky (University of Western Sydney & UWS, Australia)

15:40 *Developments of Tomography and Radar-based Head Imaging Systems*
Ahmed Toaha Mobashsher and Amin Abbosh (The University of Queensland, Australia)
Microwave-based diagnostic systems are increasingly attracting huge attention due to their low-cost, non-ionizing and non-invasive characteristics. This paper reviews the recent developments of microwave based head imaging systems reported for various applications in medical emergencies pertaining human head. The reviewed systems include tomography and radar based head imaging systems. It is shown that although microwave systems for head imaging have reached a mature stage, they still need a preclinical validation.

16:00 ***SAR Analysis Around an Implanted Cardiac Pacemaker Induced by EM Wave of VHF Band***

Kazuyuki Saito and Ryota Akiyama (Chiba University, Japan); Soichi Watanabe (National Institute of Information and Communications Technology, Japan); Koichi Ito (Chiba University, Japan)

Recently, electromagnetic interference (EMI) of an implanted cardiac pacemaker induced by a mobile radio terminal has been investigated. However, there are few studies of specific absorption rate (SAR) around the pacemaker induced by the mobile radio terminal. In particular, the SAR in such a case due to the electromagnetic wave of very high frequency (VHF) band has not been investigated. Therefore, the authors have been calculated the SAR distributions around the pacemaker model embedded into a torso model by a wireless radio terminal in VHF band. Moreover, the characteristic SAR distribution has been analyzed by the simplified model.

16:20 ***Clutter Rejection Techniques for Microwave Head Imaging***

Ali Zamani and Amin Abbosh (The University of Queensland, Australia)

Microwave head imaging is a promising technique for brain injury detection. In that technique, electromagnetic waves are sent into the head by an antenna array surrounding the head and the scattered signals are processed to form an image for brain injury detection purposes. Strong wave reflections from the outer layers of the head and their overlapping with target's signals can cause a strong clutter in the received signal. This clutter can adversely affect the accuracy of reconstructed image by masking the target response. To that end, different clutter removal techniques, including average subtraction, differential approach, spatial filtering, and entropy-based filtering are investigated in this paper. Those methods are tested in a simulation environment with a realistic head model surrounded by an 8-element antenna array. The obtained results are assessed by performance metrics to compare the ability of the investigated methods in cancelling the clutter from the received signals of microwave head imaging system.

16:40 ***Low Cost Microwave Imaging System Using Eight Element Switched Antenna Array***

Jayaseelan Marimuthu, Konstanty S Bialkowski and Amin Abbosh (The University of Queensland, Australia)

A low-cost microwave medical imaging system, which uses software defined radio (SDR) technology, is presented. SDR technology has long been used to quickly develop and prototype new communication system applications. Due to its generic nature, it has the potential to be mass-produced lowering the cost. Here, we re-purpose SDR technology to perform near-field biomedical radar with the use of a switching networking and an array of antennas. To verify its operation, two different antenna arrays using the frequency range from 1-4 GHz are used. The results show that using low-cost technology it is possible to successfully image a bio-mimicking phantom.

17:00 ***Rapid Prototyping of an Electrically-Small Antenna for Binaural-Hearing Instruments***

Andrea Ruaro (Technical University of Denmark & GN ReSound A/S, Denmark); Jesper Thaysen (GN ReSound A/S, Denmark); Kaj Bjarne Jakobsen (Technical University of Denmark, Denmark)

Rapid prototyping is emerging as a technology that can provide detailed mechanical parts, e.g., for use in antenna mock-ups, in a short lead time. Nevertheless, one of the main issues associated with it is that the materials suitable for 3D printing are not characterized at radio frequencies (RF). This study analyzes the main RF parameters (dielectric constant, loss tangent, surface roughness) and applies the results to the modeling of the prototype of an electrically small (ESA) antenna for binaural hearing instruments applications. After discussing the specific technology choices and their relevancies, it is shown how the analyzed parameters can be used to obtain good correlation between simulations and measurements.

17:20 ***Focusing Techniques in Breast Cancer Treatment Using Non-invasive Microwave Hyperthermia***

Phong Nguyen (University of Queensland, Australia); Amin Abbosh (The University of Queensland, Australia)

Different techniques for non-invasive microwave hyperthermia for breast cancer treatment are discussed. Although microwave hyperthermia was presented as a promising tool for cancer treatment, its clinical application is still far from maturity due to the drawbacks of current approaches. Hence, the main proposed techniques are explained in this paper to highlight the advantages as well as limitations of current approaches. A comparison on the system design and focusing techniques for localized heating tumor is then presented. To that end, several possible techniques to improve the focusing of microwave hyperthermia for breast cancer treatment are proposed

17:40 ***Low-Energy Bluetooth Beacons for Lifespace Assessment of People with Neurological Conditions***

David Ireland (CSIRO, Australia); Jacki Liddle (University of Queensland, Australia); Fleur Harrison, Perminder Sachdev and Henry Brodaty (University of New South Wales, Australia)

Lifespace is the geographic space in which a person lives and conducts their activities. It is recognised that having dementia is likely to constrict a person's lifespace and reduce their community participation. This work presents the application of using smart-phones and low-energy bluetooth beacons to passively measure the lifespace of participants with dementia or mild cognitive impairment (MCI) from an existing longitudinal study. Preliminary data is presented showing the mobility of a participant in their home dwelling.

S5.4: Reconfigurable antennas II

Room: Auditorium

Chairs: Jacob Coetzee (Queensland University of Technology, Australia), Tadashi Takano (Nihon University & JAXA, Japan)

15:40 *Pattern Reconfigurable Fabry-Perot Cavity Antenna*

Luyang Ji (Xidian University, P.R. China); Y. Jay Guo (University of Technology, Sydney, Australia); Ting Zhang (CSIRO, Australia); Peiyuan Qin (University of Technology, Sydney, Australia); Can Ding (University of Technology Sydney (UTS), Australia); Guang Fu (Xidian University, P.R. China); Shuxi Gong (National Laboratory of Antennas and Microwave Technology, P.R. China)

A newly designed pattern reconfigurable Fabry-Perot (FP) cavity antenna is presented in this paper. The reconfigurability is achieved by employing a phased array with a reconfigurable feed network as the source of the FP antenna. The antenna can switch its main beam direction between -10° and 10° with respect to the broadside direction from 5.36 GHz to 5.76 GHz. The realized gain of the proposed antenna is over 11.6 dBi. Good agreement between the simulated and measured results is achieved.

16:00 *Reconfigurable Antenna with Parasitic Layer Containing 8-element Dipole Array*

Md. Shahidul Alam and Amin Abbosh (The University of Queensland, Australia)

A pattern reconfigurable antenna with two layers offering successive beam tuning in two planes is proposed. A driven patch antenna is designed on the lower layer that is fed with two coaxial probes asynchronously, whereas the upper layer contains an 8-element dipole array. The electromagnetic wave is coupled from the driven patch to the eight parasitic dipoles, which then control the direction of radiation based on the status of the varactor tuning elements. To that end, eight varactors are placed in slots at the center of the parasitic dipoles to achieve the required pattern reconfigurability from the antenna. By selecting the excitation feeder and adjusting the varactor's capacitances, the radiation beam can be scanned from -30° to 30° in planes phi = 90° and phi = 0°. Furthermore, the antenna maintains more than 7 dBi gain in all the operating modes.

16:20 *Electronically-Reconfigurable Horizontally Polarized Wide-Band Planar Antenna*

Soumya Sheel and Jacob Coetzee (Queensland University of Technology, Australia)

Antennas are a necessary and critical component of communications and radar systems, but their inability to adjust to new operating scenarios can sometimes limit the system performance. Reconfigurable antennas capable of radiating in only specific desired directions can ameliorate these restrictions and help in achieving increased functionality in applications like direction finding and beam steering. This paper presents the design simulation, fabrication and measurement of a wide-band, horizontally polarized, direction reconfigurable microstrip antenna operating at 2.45 GHz. This design employs a central horizontally polarized omnidirectional active element surrounded by electronically reconfigurable parasitic microstrip elements, controlled by PIN diodes acting as RF switches. Experimental results show that the reconfigurable antenna has a bandwidth of 40% (2-3 GHz), with 3 dB gain in the desired direction and capable of steering over the 360° range.

16:40 *Wideband ± 45^0 Polarization Reconfigurable Aperture-Fed Patch Antenna*

Wei Lin and Hang Wong (City University of Hong Kong, Hong Kong)

A wideband aperture-fed patch antenna with ± 45^0 reconfigurable polarizations is introduced. A cross aperture controlled by PIN diodes to excite a square patch for achieving the switchable ± 45^0 polarizations is proposed. In order to widen the bandwidth of a single patch antenna, we introduce a parasitic patch placed above the driven patch to have an additional resonance. The bandwidth of the stacked-patch structure reaches 21%. In addition, the antenna has a stable gain across the operating bandwidth with the peak gain of 9.6 dBi. Good broadside radiation patterns are obtained with the 3-dB beamwidth of 56 degree. The antenna is suitable for applications requiring wideband and polarization reconfigurable characteristics.

17:00 *Design of the Transmission and Reception Antennas for Beamed Power Transfer*

Tadashi Takano (Nihon University & JAXA, Japan)

This paper proposes the design method of the antennas for beamed power transfer. The transmission antenna is composed of arrayed radiating elements of which the phase is designed to form a concave phase front. The focusing capability is dependent on the size of the transmission antenna, frequency, and the distance to the reception antenna. The simulation analysis clarifies the characteristics of the transmitted beam. Subsequently, the reception antenna is determined according to the obtained beam profile.

17:20 *Low Profile Switched Beam Utilizing A Ring-Parasitic Antenna*

Pichaya Chaipanya (Srinakharinwirot University, Thailand)

This paper presents a low profile switched beam antenna for wireless communications at 2.45 GHz. There are eight-beam patterns, 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°, which can be controlled by shorted circuit at different positions of small circular elements of parasitic ring. The antenna is created in simulation from CST Microwave Studio. The obtain results show that the proposed antenna cannot only capable to beam switching but also increase gain of the antenna.

08:00 - 10:20

S1.5: Computational electromagnetics I

Room: Tasman A

Chairs: Konstanty S Bialkowski (The University of Queensland & National ICT Australia, Australia), Thierry Gilles (Royal Military Academy & LEMA, Belgium)

08:00 ***Radiation Performance Enhancement of a Compact Fabry-Perot Cavity Antenna Using Particle Swarm Optimization***

Maria Kovaleva, Basit Ali Zeb, David Bulger and Karu Esselle (Macquarie University, Australia)

A Fabry-Perot cavity antenna (FPCA) with a compact single-layer all-dielectric superstructure is designed using particle swarm optimization (PSO). The PSO algorithm, implemented in a MATLAB code, considers Ackley function to achieve stable convergence by adjusting its internal parameters. We performed single-objective optimization using an objective function that maximizes the sum of boresight directivities at three distinct frequencies. It was found that peak directivity of 19 dBi and 3-dB directivity bandwidth of 24% can be achieved by optimizing the permittivity distribution of the superstructure with a diameter of 2.2λ0.

08:20 ***Interpretation of Complex Frequencies in Propagation Problems***

Walid Dyab (Polytechnique Montreal, Canada); Christophe Caloz (Ecole Polytechnique de Montreal, Canada); Simon Otto (University Duisburg-Essen, Germany)

Derived from Helmholtz wave equation, the dispersion relation describes the temporal and spatial behaviors of a wave in a given electromagnetic medium. In general, this relation can yield wave solutions of complex propagation constant with real temporal frequencies, as well as solutions of real propagation constants with complex temporal frequencies. While the former is a natural case which corresponds to attenuated or totally evanescent waves, the latter is not very familiar. This paper presents the example of a periodic leaky-wave antenna whose dispersion relation gives rise to wave solutions with complex temporal frequencies. The physical significance of such solutions is explained

08:40 ***Multiple Edge Interaction Effect to Plane Wave Scattering by a Wide and Thick Slit***

Masayuki Shimizu and Hiroshi Shirai (Chuo University, Japan); Ryoichi Sato (Niigata University, Japan)

High frequency ray method has been applied to formulate E-polarized plane wave scattering by a wide and thick slit. Slit aperture region is considered as a waveguide which connects upper and lower half spaces, and excitations of the waveguide modes are given by edge diffraction at the open end. Multiple edge diffraction effect as well as modal bouncing effect are also considered to improve the accuracy of the scattering field.

09:00 ***Simultaneous Estimation of DOA and Angular Spread of Incident Radio Waves by DOA-Matrix Method with SLS and SAGE Algorithms***

Makoto Jomoto, Nobuyoshi Kikuma and Kunio Sakakibara (Nagoya Institute of Technology, Japan)

In estimating DOA of incident waves with high accuracy, we often have to take into consideration the angular spread of each wave due to reflection, diffraction, and scattering. As a method of estimating DOA and AS simultaneously, SAGE-DOA-Matrix method was proposed which uses DOA-Matrix method along with SAGE algorithm. In this paper, we further improve the performance of the method by using SLS algorithm. Through computer simulation, we demonstrate the effectiveness of the improved method.

09:20 ***Analytical Evaluation of Reflection Characteristics of Metal Plate Loading FSR with Diagonal Incident Wave***

Shuhei Iwakata, Shigeru Makino, Keisuke Noguchi, Tetsuo Hirota and Kenji Itoh (Kanazawa Institute of Technology, Japan)

We showed a simple equation to calculate reflection phase of metal plate FSR in the diagonal incident. In addition, we showed a method of measurement and device of the reflectance to measure a diagonal incident wave easily. Finally, we examined by comparing the simple equation with MoM and measurements. In consideration of a production error or a measurement error, we consider that the simple expression derived in this study is proper.

09:40 ***Quantitative Analysis of the Amplitude Difference Between Near and Far Field Directivity***

Thierry Gilles (Royal Military Academy & LEMA, Belgium); Tran Dung (Royal Military Academy, Belgium)

In this short paper we briefly revise the criteria defining near and far field. After an extension of the radian sphere notion to finite size sources, we generalize the amplitude and phase criteria for arbitrary source structures. Next we identify with a representative example the wavelength distance where the near field has reached the shape of the far field directivity, then we quantify the difference between near and far field directivity in function of the position to the source

10:00 *Well-conditioned EFIE-TDS Surface Integral Equation*

Yi-Ru Jeong and Jong-Gwan Yook (Yonsei University, Korea); Ic Pyo Hong (Kongju National University, Korea); Kyung-Won Lee (Yonsei University, Korea); Sam Yeul Choi (LIG Nex1 Co., Korea)

A well-conditioned coupled set of electric field integral equation(EFIE) and thin dielectric sheet(TDS) approximation surface integral equations for analyzing densely discretized composite structures with perfect electric conductor(PEC) and thin dielectric layer is proposed. Whereas TDS operator is well-posed, a EFIE operator is ill-posed when applied to densely discretized surfaces. This makes the coupled EFIE and TDS linear system ill-conditioned, and its iterative solution inefficient or even impossible. The proposed method regularizes the coupled set of EFIE-TDS using a Calderon multiplicative preconditioner(CMP) technique. The resulting linear system enables the efficient analysis of composite structures with PEC and thin dielectric layer. Numerical example validates the efficiency of the proposed method

S2.5: Mobile and indoor propagation I

Room: Tasman B

Chairs: Takahiro Hashimoto (Mitsubishi Electric Corporation, Japan), Minoru Inomata (NTT Corporation, Japan)

08:00 *Indoor Propagation Estimation Combining Statistical Models with Ray-Tracing*

Takahiro Hashimoto, Yasuhiro Nishioka, Yoshio Inasawa and Hiroaki Miyashita (Mitsubishi Electric Corporation, Japan)

In order to improve estimation accuracy of the statistical model, we present a novel method. In this method, we classify NLoS region using number of reflections and diffractions calculated by ray-tracing, and then applies different statistical models to each regions. First, we classify NLoS region using the conditions up to 3 times reflections, 1 times diffraction, and others. Then we compare fitting errors of the statistical models. The fitting error decreased from 4.18 dB to approximately 3 dB after some classification, but the fitting error did not decrease furthermore. Next, we evaluate the calculation errors of the developed statistical models. The calculation error became minimal of 3.77 dB when we classify NLoS into up to 2 times reflection and others, and then tended to increase when we classify further. From the above results, it is optimal that the NLoS region is classified into 3 regions.

08:20 *A Comparative Study of Wireless Channel Propagation Characteristics in Industrial and Office Environments*

Yun Ai (Gjøvik University College & University of Oslo, Norway); Michael Cheffena (Gjøvik University College, Norway)

This paper presents the comparative results of channel measurements in an industrial facility and an indoor office. The frequency domain channel measurements have been carried out in the frequency band of 0.8--2.7 GHz. Results on channel characteristic parameters such as large-scale path loss, shadowing, power delay profile (PDP), root-mean-square (rms) delay spread, Ricean K-factor and the multiple-input and multiple-output (MIMO) channel capacity measurements for indoor office and industrial scenario are presented and compared. The results indicate some different channel propagation characteristics of the industrial wireless channel from the indoor office channel owing to its different physical characteristics. The differences might need to be taken into further consideration when designing reliable industrial wireless communication system.

08:40 *Outdoor-to-Indoor Path Loss Model for 8 to 37 GHz Band*

Minoru Inomata (NTT Corporation, Japan); Wataru Yamada (Nippon Telegraph and Telephone Cooporation, Japan); Motoharu Sasaki (NTT Access Network Service Systems Laboratories, Japan); Takeshi Onizawa (NTT Corporation, Japan)

This paper proposes a path loss model that can cover the high frequency bands above 6 GHz. The path loss characteristics are analyzed on the basis of measurement results obtained using the 8 to 37 GHz band in outdoor-to-indoor environments. It is clarified that the characteristics depend on the incident azimuth angle, incident elevation angle, and frequency. By taking these dependencies into account, the proposed model can decrease the root mean square error of predicted results to about from 2.1 to 5 dB in the 8 to 37 GHz band.

09:00 *Time-Reversal Based Routing in Dispersion Code Multiple Access (DCMA)*

Lianfeng Zou (Ecole Polytechnique de Montreal & Poly-Grames Research Center, Canada); Shulabh Gupta (École Polytechnique de Montréal, Canada); Christophe Caloz (Ecole Polytechnique de Montreal, Canada)

An adaptive Dispersion Code Multiple Access (DCMA) system is proposed and demonstrated using numerical calculations. Compared to conventional static DCMA, where channels between access points are fixed unless adaptive phasers are used, the proposed system employs a base-station which allows users with distinct but fixed phasers to form arbitrary adaptive channels between the access points. The base-station first records the channel responses in the sounding stage, and then uses this information to route the data between arbitrary user pairs in the communication stage.

09:20 *Measurement of Indoor Channel Characteristics At 20 GHz Band*

Ngochao Tran, Tetsuro Imai and Yukihiko Okumura (NTT DOCOMO, INC., Japan)

To enable the 5G system, one of the most important issues is to clarify propagation characteristics at high frequency (over 6 GHz) bands. This paper presents the channel characteristics at 20 GHz band for indoor office environment. The measurements were carried out by using a channel sounder at 20 GHz band with 50 MHz bandwidth of OFDM signal. The 19 dBi horn antenna was rotated in both azimuth and elevation directions at receiver side in order to enable measure Power Delay Profile (PDP) at each angle. By combining all PDPs, the channel characteristics as if using omni-directional antenna were estimated. The measured and estimated results show that the pass losses are smaller than path losses in free space condition. The averages of delay spreads, azimuth angle spreads, elevation angle spreads are 60.4 ns, 64.7 degrees, 3.6 degrees, respectively. The standard deviations of delay spreads, azimuth angle spreads and elevation angle spreads are 9.7 ns, 10.7 degrees and 3.1 degrees, respectively.

09:40 *TDOA Fingerprinting for Localization in Non-Line-of-Sight and Multipath Environments*

Johannes Schmitz (RWTH Aachen University, Germany); Florian Schröder (SmartWireless GmbH & Co. KG, Germany); Rudolf Mathar (RWTH Aachen University, Germany)

Localization in urban areas with no direct line-of-sight between the target and anchor nodes turns out to be challenging for many well-known localization methods. In combination with multipath propagation of employed radio waves, the performance of the location estimates can be heavily deteriorated. In this paper we introduce a multilateration method that is able to cope with such conditions. Employing a discrete approach for the estimation of the emitter location, we show how prior knowledge of the environment, obtained from a ray tracer or ray launcher, can improve the system accuracy. The localization algorithm is based on time differences of arrival between the observing sensors. However, in non-line-of-sight these time differences change as opposed to common signal models that assume free-space propagation. This mismatch is resolved taking into account information of the propagation paths provided by the ray launcher. Simulation results demonstrate that the proposed method effectively mitigates the impact of non-line-of-sight and multipath propagation on the location accuracy.

10:00 *Performance Evaluation of Active Propagation Control in a Three-Dimensional Indoor Environment*

Kenichiro Kamohara, Hisato Iwai and Hideichi Sasaoka (Doshisha University, Japan)

We can improve transmission performance of wireless communications by changing propagation environment actively and appropriately. We call such method "Active Propagation Control" (APC). In the previous studies we showed the fundamental effectiveness of APC by two-dimensional FDTD analysis, assuming an empty Room where a metal plate is rotated as a device changing the propagation characteristics. In this paper, we analyze indoor propagation characteristics by using the three-dimensional FDTD method so as to discuss more accurate amount of the improvement of APC in a three-dimensional space. In addition, we change the position of the metal plate besides its size in order to evaluate the effect of the variations on the improvement of APC. In the evaluation, we assume a SISO wireless communication and show the reduction of path loss by APC quantitatively.

S3.5: Radar and satellite systems I

Room: Tasman C

Chair: Chad Hargrave (CSIRO, Australia)

08:00 *Radar Target Recognition Using Selective Resonance Excitation*

Chad Hargrave (CSIRO, Australia); Vaughan Clarkson (The University of Queensland, Australia)

Resonance-based radar target recognition is premised on the observation of natural resonant frequencies so that target discrimination and classification can occur. This implies the use of ultra-wideband (UWB) radar in order to excite a sufficiently wide range of target frequencies, however developing practical UWB radar systems is a significant challenge. Furthermore, due the relative weakness of the late-time resonant target response, it is often not possible to isolate the resonant frequencies under realistic noise conditions. To mitigate these limitations, this paper examines the feasibility of selective excitation of resonant frequencies using more traditional (narrow-to-medium band) excitation. Simulated target results are presented for which resonant frequencies are extracted, and the efficacy of selective excitation of these resonances is demonstrated.

08:20 *Dimension Estimation of Polygonal Dielectric Targets From Surface Reflection RCS*

Kisumi Asuka and Hiroshi Shirai (Chuo University, Japan)

A method has been proposed here to estimate the facet's size of polygonal dielectric targets using the specular reflected RCS.The formulation is based on the high frequency assumption that the target is large compared with the wavelength. It has been found from our scattering analysis by metal/dielectric polygonal objects that the specular reflected RCS peaks and nulls have some important information of a reflected facet size, and a reconstruction algorithm of cylindrical metal objects has been tested for polygonal and smooth cylinders. This algorithm has been tested to estimate the size of dielectric cuboids from the measurement data. Good accuracy has been found and the validity of our method is confirmed.

08:40 *Interferometric Three-Dimensional Imaging for Spinning Targets Based on Narrow-Band Radar*

Chao Sun, Baoping Wang and Yang Fang (Northwestern Polytechnical University, P.R. China)

In this paper, a novel interferometric 3-D imaging algorithm for spinning targets is proposed based on narrow-band radar. The height information of the scatterer is estimated by the phase difference between the same scatterer in two 2-D images generated by two antennas at closely-separated elevation angles via narrow-band radar imaging algorithms. For imaging of rapidly spinning targets, however, spurious peaks appear due to azimuth sample deficiency. Furthermore, the compressed sensing theory is applied into interferometric 3-D imaging based on joint sparsity of two images. The simulation results have proved the validity of the proposed algorithm.

09:00 *Incoherent Scattering Analysis for Radar Clutter*

Jae-Ho Lee and Dong-Wook Seo (Electronics and Telecommunication Research Institute (ETRI), Korea); Mi-Ryung Park (ETRI, Korea)

This paper proposes a method to estimate directly the incoherent scattered intensity and radar cross section (RCS) from the effective permittivity of random media. The proposed method is derived from the original concept of incoherent scattering. The incoherent scattered field is expressed as a simple formula. Therefore, the proposed method can estimate the incoherent scattered intensity and RCS of random media for reducing computation time. To verify the potentials of the proposed method for the desired applications, we conducted an additional the Monte-Carlo analysis using the method of moments (MoM), and characterized the accuracy of the proposed method using the normalized mean square error (nMSE). In addition, several medium parameters such as the density and analysis volume were studied to understand their effect on the scattering characteristics of random media. The results of the Monte-Carlo analysis show good agreement with those of the proposed method.

09:20 *A Study on Metal-Insensitive Antenna for Closed Space Wireless Communications*
Yuta Nakagawa, Shingo Tanaka, Tatsuo Toba, Tsuneto Kimura and Kenji Shirasu (Yazaki Corporation, Japan); Takashi Oki and Naoto Nishiyama (National Defense Academy, Japan); Hisashi Morishita (National Defence Academy, Japan)
In order to obtain metal-insensitive antenna for closed-space wireless communications, the impedance characteristics of U-shaped folded monopole antenna is investigated in detail. The simulated and measured results show that the proposed higher impedance model has stronger metal-insensitiveness than the conventional middle impedance model. The limitation value of hgp (distance between antenna and metal plane) in order to obtain S11≤0.5 (VSWR≤3) is 5 mm for the conventional middle impedance model and 2 mm for the proposed higher impedance model, respectively. The simulated results show that the antenna gains of higher impedance models are 3dB greater than those of middle impedance models.

09:40 *Dual Circularly Polarized Waveguide Antenna Array for Satellite Communications in the X Band*
Yong-Qing Zou, Hong-Tao Zhang, Wei Wang and Mou-Ping Jin (East China Research Institute of Electronic Engineering, P.R. China)
In this paper, a novel dual circular polarization waveguide antenna array with wide band and low axial ratio is presented at X-band. Planar horn array is used to attain dual circular-polarization working with orthomode transducer and rectangular side wall coupler. A demo array of 16×16 elements is designed, manufactured and tested. The experimental results show that the AR is less than 1. 5dB; the VSWR is less than 1.5 in the operation frequency band.

10:00 *An Industrial Application of Ground Penetrating Radar for Coal Mining Horizon Sensing*
Jonathon Ralston (CSIRO Energy, Australia)
Effective mining horizon sensing is an issue of major importance in the coal mining industry because it directly impacts the productivity and safety of the resource recovery process. However the development of automated mining horizon control capability has been significantly hindered by a fundamental lack of sensing that can reliably measure the coal-strata geological structure in the subsurface. In an attempt to advance practical solutions for this problem, this paper reports on the industrial application of radar technology at a production open cut coal mine. Here the use of ground penetrating radar (GPR) has been extensively evaluated through a series of extensive campaigns for detecting and discriminating subsurface geological strata boundaries. The mining scenario, experimental design, data collection, and validation processes are given in order to demonstrate the efficacy and challenges of using GPR for this horizon sensing application. This tutorial-style paper is intended to assist practical application of radar technology into industry

S4.5: EBG, metamaterials and periodic structures I

Room: Wellington

Chairs: Tao Hong (Xidian University, P.R. China), Zhongxiang Shen (Nanyang Technological University, Singapore)

08:00 *A Loop Resonator for 3-D Frequency Selective Structure*
Ahmed Abdelmottaleb Omar and Zhongxiang Shen (Nanyang Technological University, Singapore)
A loop resonator for the 3-D frequency selective structure is proposed aiming to reduce the thickness of the structure and introduce a new type of resonator inside the unit cell. The structure is based on the coupling between the two modes concentrated in the unit cell to obtain transmission and reflection zeros. The new resonator reduces the thickness of the structure by 28.5% compared to the previous structures, this resonator open the way for more resonators to be involved in. the proposed resonator shows stable performance under oblique angles of incidence for the single-band and dual-band structures. The operating concept and simulation results are included.

08:20 *Design of a Dielectric Phase-Correcting Structure for an EBG Resonator Antenna Using Particle Swarm Optimization*
Ali Lalbakhsh, Muhammad Usman Afzal, Basit Ali Zeb and Karu Esselle (Macquarie University, Australia)
This paper presents a novel method to design an all-dielectric phase correcting structure (PCS) to improve phase uniformity on the aperture of a classical electromagnetic band gap resonator antenna (ERA). This PCS has fixed permittivity, but varying thickness in a plane perpendicular to the dominant radiated E-field component. A particle swarm optimization (PSO) algorithm and a commercial time-domain solver are combined to optimize the PCS thickness. The proposed PCS not only significantly reduces the phase non-uniformity, but also improves the broadside directivity of the ERA by 4.6 dBi.

08:40 *Mutual Conversion and Asymmetric Transmission of Linearly Polarized Waves Based on Metamaterial*
Linbo Zhang, Jun Luo, Peiheng Zhou, Haiyan Chen, Jianliang Xie and Longjiang Deng (University of Electronic Science and Technology of China, P.R. China)
In this paper, we propose a simple bilayered chiral metamaterial (CMM) consisting of two layers of split oval ring resonators by twisted angle of 90°. Numerical simulated results demonstrate that the proposed structure can realized a mutual polarization conversion and dual-band asymmetric transmission of linearly polarized waves in two opposite directions. The structure can convert the linearly polarized (LP) waves to its cross-polarized waves at 12.4 GHz and 14.6 GHz, respectively. The bandwidth of polarization conversion ratio (PCR) over 80% can be achieved from 12.5 to 17.7 GHz.

09:00 *Novel Three-Dimensional Frequency Selective Surface with Incident Angle and Polarization Independence*

Cheng Wang (Nanjing University of Science and Technology, P.R. China); Wei Zhuang and Wanchun Tang (Nanjing Normal University, P.R. China)

In this paper, a novel three-dimensional frequency selective surface (3D FSS) which is independent of incident angles and polarizations is presented. The periodic unit cell of the proposed 3D FSS is composed of a square metallic waveguide with modified dumbbell slots in all waveguide walls. Frequency transmission characteristics of this 3D FSS for both TE and TM polarizations under different incident angles are simulated. From the results, it is founded that the proposed 3D FSS can provide excellent frequency stability for different incident angles and polarizations. What's more, using 3D printing technology, the novel 3D FSS will be easy for fabrication.

09:20 *Electromagnetic Scattering Properties of Cylindrical Frequency Selective Surface*

Zhi-Hang Liu, Shuang Ma, Guohui Yang, Shao-Qing Zhang and Wu Qun (Harbin Institute of Technology, P.R. China)

In this paper, the electromagnetic scattering properties of Curved Frequency Selective Surface conformal to a cylinder surface is investigated. Four unit models are used to realize required reflection and transfer characteristics in a wide band range. Simulation shows far field radiation directivity pattern and RCS diagram of cylindrical FSS. The feature influence factors by the structure unit, the curvature of the cylindrical FSS and the dielectric-slab parameters (the thickness of the plate and the dielectric constant) are discussed.

09:40 *A Switchable FSS Based on Modified Jerusalem-Cross Unit Cell with Extended Top Loading*

Hijab Zahra and Syed Muzahir Abbas (Macquarie University, Australia); Muhammad Farhan Shafique (COMSATS Institute of Information Technolgy, Pakistan); Karu Esselle (Macquarie University, Australia)

This paper presents a switchable frequency selective surface (FSS) based on a modified Jerusalem-cross (JC) unit cell with extended top loading. Various combinations of switches are considered to make it switchable and the corresponding FSS behavior is analyzed. It is noted that the pass band(s) and stop band can be achieved by turning switches ON or OFF appropriately. For example, as a band pass FSS, it can provide single wide-band operation covering a bandwidth of 1.5GHz (2.97-4.47 GHz). In another mode, two narrower pass bands, one around 2.4GHz and other around 5.4GHz, can be achieved. Third mode allows a very wide stop band. The proposed FSS unit cell has been designed to fabricate on FR-4 to provide an inexpensive reconfigurable solution.

10:00 *Ultra Wide Band Frequency Selective Absorber with Asymmetric Absorbing Performance*

Tao Hong (Xidian University, P.R. China); Qiang Chen (Tohoku University, Japan); Shuxi Gong (Xidian University, P.R. China)

In this paper, a frequency selective absorber (FSA) with asymmetric performance is proposed. Modified log-periodic dipole array (LPDA) elements are applied to construct the FSA. With the ultra wide band (UWB) property of the LPDA-shaped elements, the FSA gets the UWB absorbing band. Due to the directionality of the LPDA, the FSA is asymmetric network which means that the reflection coefficients of the FSA are different when the incident wave lit the two surfaces respectively. Simulations and analysis are done to study the UWB and absorbing properties. The results show that the proposed FSA can effectively absorb or reflect the incident wave in 6.45GHz-20GHz when the incident wave lit the two surfaces respectively.

S5.5: RFID and wireless sensing I

Room: Auditorium

Chairs: Mohamad Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia), Nemai Karmakar (MONASH University, Australia)

08:00 *Topology Optimization of Tag Structures for Chipless RFID*

Yuta Watanabe (Tokyo Metropolitan Industrial Technology Research Institute, Japan)

This paper presents shape optimization of chipless RFID tag. In the present optimization, the chipless tag characteristics are analyzed by the finite-difference time-domain method. The shapes of chipless tag are optimized by using the micro genetic algorithm and on-off method with moving average filter in order to maximize the amplitude and quality factor of backscattering wave from chipless tags. The optimized chipless tag has higher amplitude and quality factor of backscattering wave.

08:20 *On-road Slot Antenna with Corrugated Ground for Road-Curtain Machine-to-Machine RFID Application*

Yifan Wang (University of Queensland, Australia); Amin Abbosh (The University of Queensland, Australia)

A novel slot antenna designed on the road surface for machine-to-machine (M2M) RFID communication is presented. A corrugated ground plane with perturbed surface impedance is used underneath the antenna's radiator to adjust the antenna's radiation pattern, which otherwise will be highly affected by the properties of the road surface. The proposed antenna configuration is verified by full-wave simulations with various road surface conditions. The results show that the antenna has a stable performance with different road conditions. It possesses more than 12 dB return loss, more than 1.4 dBi gain, vertical polarization, and desirable radiation pattern from 880 MHz to 960 MHz.

08:40 *Development of Nearby Cluttered Tags Detection Unit with UHF-RFID Technology*

Kyosuke Mayama and Yoshinobu Okano (Tokyo City University, Japan)

Recently, the system for closely-spaced tag management (at 13.56 MHz) and the system for the long distance identification (at 920 MHz) have been carried out to practical use now. For continuous logistics, it is desired that those are integrated seamlessly. However, integration into the system, which uses the frequency band of 13.56 MHz, is disadvantageous to keep the feature of the long distance identification. In this report, the system which identifies two-dimensional cluttered tags by the frequency band for the long distance identification is described.

09:00 ***Small-size Tag Antenna for UHF Active RFID System***

Jui-Han Lu and Hai-Ming Chin (National Kaohsiung Marine University, Taiwan)

This work describes a novel compact design of planar ultra-high-frequency (UHF) tag antenna for radio-frequency identification (RFID) system by introducing an L-shaped metal plate connecting with the spiral monopole antenna. The obtained impedance bandwidth of 12 MHz can meet with Taiwan UHF operating band (922 ~ 928 MHz). The overall antenna size is only 13 × 9 × 1.6 mm3. The measured peak gain and antenna efficiency are approximately -1.1 dBi and 27 % for Taiwan UHF band, respectively. Meanwhile, the measured reading distance can approach 250 m. Good tag sensitivity is obtained across the desired frequency band.

09:20 ***Detection Range Enhanced Antenna Using a Triple Polarization Switching for Mobile UHF RFID Applications***

Lee Dongjin (Korea Advanced Institute of Science and Technology(KAIST), Korea); Seung-Tae Khang and Soo-Chang Chae (KAIST, Korea); Soo-Ji Lee (Korea Advanced Institute of Science and Technology(KAIST), Korea); Jong-Won Yu (KAIST, Korea)

In this paper, we present a detection range enhanced antenna for mobile ultra-high frequency (UHF) RFID (Radio-frequency identification) applications. For the detection rage enhancement, triple polarization switching is used with a pair of parallel dipoles and a feeding network. The pair of parallel dipoles placed orthogonally each other to make a three polarization states by controlling the switches on the feeding networks. With the compact size of the antenna, the proposed antenna can generate two orthogonal linear polarizations and right hand circular polarization. The use of the proposed antenna may lead to polarization mismatch loss thus increasing the possible tag reading distance. Experimental results show that the proposed antenna of size 76 * 76 * 15 mm3 has the peak gain of 2.05dBi for linear polarization and 1.45dBic for RHCP.

09:40 ***Compact Chipless RFID Metamaterial Based Structure Using Textile Material***

Mohd Ezwan Jalil, Mohamad Kamal A. Rahim, Noor Asmawati Samsuri and Raimi Dewan (Universiti Teknologi Malaysia, Malaysia)

A novel multi-resonator using rectangular slotted complementary split ring resonator (CSRR) on planar transmission line is proposed for the design of chipless RFID tag. The chipless design consists of 4 rings resonator which etched on the back of the substrate and connected to 50 ohm planar transmission line. Each resonator enable to code in four different allocations (00, 01, 10, 11) with bandwidth allocation of 200 MHz. The 8 bits chipless tag with low insertion loss (below -13 dB) operates from 2.5 to 6.5 GHz The 25 mm × 20 mm flexible chip-less RFID tag is designed on the fleece substrate (ε^r=1.35, thickness = 1mm , tan δ=0.025). At the end, the effects of orientation of split ring resonator, number of element and material types are studied and analyzed.

10:00 ***Short Time Fourier Transform (STFT) for Collision Detection in Chipless RFID Systems***

Rubayet Azim (Monash University, Australia); Nemai Karmakar (MONASH University, Australia); Emran Amin (Monash University, Australia)

This method proposes a novel collision detection methodology in chipless RFID system. The tags are interrogated by a impulse radio ultra wideband signal (IR-UWB). The collided backscattered signal received from the interrogation zone is analyzed in time-frequency plane through Short Time Fourier Transform (STFT). From the time-frequency representation, multiple tag IDs can be easily decoded. The simulation results prove the potentiality of the method as an efficient collision detection technique for chipless RFID systems.

10:40 - 11:30

S5.6.1: Keynote 3 - The Mesmerizing Evolution of Reflector Antennas in Diverse Applications: A Passage from the Ancient Past to the Renaissance and the Present

Prof Yahya Rahmat-Samii - Distinguished Professor Member of the US National Academy of Engineering Department of Electrical Engineering University of California, Los Angeles, USA
Room: Auditorium
Chair: Y. Jay Guo (University of Technology, Sydney, Australia)

A casual Internet search yields over one million web sites associated with the phrase "reflector antenna". This author was so fascinated by a typical reflector antenna shape that when he designed the winning IEEE Antennas and Propagation Society Logo he used a rendition of a reflector antenna in the logo artwork. This logo design now appears on thousands of publication materials related to the IEEE antenna publications, symposia flyers and books, etc. This depiction of an antenna is the most recognized form of any antenna by the general public. Throughout the history of mankind, the reflector antenna has seen a wide range of applications since among other antenna configurations it provides the highest gain, widest bandwidth, and best angular resolutions at the lowest costs. Simply stating, the primary role of a reflector antenna is to confine or radiate most of the electromagnetic energy over its aperture into a focal plane in receive mode or radiate to the far fields for communication or energy transfer in transmit mode. Typical reflector antennas use conic sections, the parabola, ellipse, hyperbola, and sphere, to either focus or efficiently radiate electromagnetic waves. Reflector antennas are typically categorized according to radiation pattern type, reflector surface type, and feed type. Pencil-beam reflectors are the most popular and are commonly used in point-to-point microwave communications and telemetry, since they yield the maximum gain and typically their beam directions are fixed at the time of antenna installation. In satellite communication systems, the uplink pencil-beam is typically steered by moving the reflector, or steering over a limited range using the feed. Recent generations of satellite reflectors have produced other popular types of radiation pattern classifications: contour (shaped) beams and multiple beams. These applications require reflectors with improved off-axis beam characteristics and non-standard conical shapes. Demand for high performance large reflector antennas for space applications have necessitated the development of various deployable concepts, such as, mesh and inflatable designs. Radio astronomy and deep space communications have also resulted into fascinating reflector antenna developments and engineering. In this keynote talk, the development of reflector antennas, from the ancient past to the Renaissance to the present, is reviewed in a concise and novel fashion, along with inferences to present and future developments. The material presented in this overview talk is the summarized version of many journal and conference papers and book chapters co-authored by the author and his contributions to the original designs of many currently functioning communications, remote sensing, and radar antenna systems.

11:30 - 12:20

S5.6.2: Keynote 4 - Antennas and Quasi-optics For Space Terahertz Instrumentation

Dr Peter de Maagt - European Space Agency
Room: Auditorium
Chair: Y. Jay Guo (University of Technology, Sydney, Australia)

This paper will give an overview of some of the antennas and quasioptical components that are used in space instruments. Herschel and Planck observatories will be used as an example to demonstrate the hurdles that had to be overcome. Several Earth observation instruments and astronomical missions which use millimetre and submillimetre wavebands, have been developed or are being planned by ESA. These instruments have many commonalities in their design and construction techniques. One of the issues that the above missions have in common is that they require state-of-the-art technology to achieve their ambitious goals; the highest resolution, the highest sensitivity, the highest frequency of operation. Although technology is advancing at a rapid pace in this frequency range, the requirements for these instruments go well beyond those of related existing (sub)millimetre wave instruments. This has resulted in the need for new antenna configurations and in the refinement of existing configurations and technologies for top performance. Furthermore, it has to be recognized that there are also no standards or calibration reference sources in this field which complicates the procedures to verify the RF performance under flight conditions. Antenna performance is a critical aspect in millimetre-wave and submillimetre-wave limb sounding, since it determines the resolution and accuracy with which the concentration profiles of atmospheric species can be retrieved. Antenna performance is also a critical aspect of millimetre-wave and submillimetre-wave astronomical missions. For pointed observatories, which seek to map point-like or not very extended objects, the emphasis is then on beam efficiency and the control of main beam shapes. For survey missions, the level of far side lobes also becomes very important and in some cases (such as PLANCK) this exerts a critical influence on the success of the mission. The paper will discuss a range of THz applications and will present the antenna, their feed assemblies and quasi-optical components and systems that are utilised for the frequency region. It will also highlight the procedure that had to be adopted in order to verify RF performance under flight conditions. ESA's Herschel and Planck observatories will be used as an example to highlight some of the hurdles that had to be overcome for verification of flight-performance.. Some scientific results that have been obtained from the recent missions will also be shown. Upcoming mission will be discussed.

13:00 - 15:20

S1.7: Microwave imaging for biomedical and other applications I

Room: Tasman A

Chairs: Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia), Sergey Kharkovsky (University of Western Sydney & UWS, Australia)

13:00 *Microwave Heartbeat Detection by Suppressing Respiration Component*

Shinya Yonezawa and Naoki Honma (Iwate University, Japan); Kentaro Nishimori (Niigata University, Japan)

The authors have proposed a non-contact vital sign detection method using a microwave. In general, the body surface movement due to respiration is significantly larger than that of heartbeat, and this obstructs heartbeat detection. In this paper, we propose the microwave heartbeat detection method by suppressing the respiration component. Measurements were carried out in a multi-path environment, and the experimental results showed that the proposed method works well in detecting heartbeat.

13:20 *Automated RF Tomographic Imaging of Utility Poles Above and Below Ground*

David G Johnson and Graham Michael Brooker (University of Sydney, Australia)

This paper describes the development of a 3-D scanning system and associated signal processing for carrying out non-destructive imaging of wooden utility poles. While nominally rod-shaped, natural variations in the original tree, its cut, and any attached street furniture impose considerable complexity to automating the task of scanning a pole. While RF tomographic techniques are theoretically capable of producing images of sufficient quality to assess pole degradation, spectrum constraints; the need for a low-cost, efficient and reliable scanning device and the additional complexity of making sub-surface measurements through heterogeneous material combine to make this a challenging task. Ground-truth data obtained from a medical CT scanner and a customised experimental apparatus will therefore be described, along with progress made in the selection of appropriate scanning and processing mechanisms.

13:40 *Improved DORT for Breast Cancer Detection in Low Contrast Scenarios*

Md Delwar Hossain (Faculty of Engineering and IT, University of Technology Sydney (UTS), Australia); Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia)

Microwave imaging performance deteriorates with increasing clutter and heterogeneity in the imaging medium. Breast cancer detection becomes increasingly challenging with increasing breast density. Decomposition of the time reversal operator (DORT) uses signal subspace of the multistatic matrix which is perturbed in highly heterogeneous medium. To overcome the problem we propose coherent processing in frequency domain prior to imaging operation. Coherent DORT provides robust imaging performance compared to conventional non-coherent DORT in cluttered medium as evident from the imaging results obtain using anatomically realistic numerical breast phantoms.

14:00 *Human Head Modelling At Microwave Frequencies Using Open-Source Electromagnetics Solver*

Yifan Wang (University of Queensland, Australia); Amin Abbosh (The University of Queensland, Australia)

A computational electromagnetics platform that can be used to study interactions between electromagnetic fields and human tissues is presented. The developed platform uses pre-existing triangle-represented geometry models and associated dielectric properties to create a finite-difference time-domain (FDTD) computation environment beyond the open-source MATLAN toolbox. Compared with most commercial simulation platforms, the presented platform provides a highly-transparent user interface to solve the complex electromagnetic scattering problems with adjustable texture resolution based on the skin depth value. Furthermore, the open-source functions under this platform can be easily integrated with other external MATLAB programs to conduct an algorithm-controlled computational project. As an example of the presented platform, the modelling and simulating of microwave signals propagation and scattering in a realistic human model are explained.

14:20 *Robust Spectral-Domain EM Modeling of Distributed-Source Sensors in Planar-Layered Media*

Kamalesh Sainath (Ohio State University & ElectroScience Laboratory, USA); Fernando Teixeira (Ohio State University, USA)

We report a rapid, robust full-wave methodology to model electromagnetic (EM) wave radiation by distributed current sources embedded in planar-layered media. Primitive causality-related numerical instabilities within the computation chain, induced by exponentially rising ``distributed" current source spectrum functions, are addressed for both linear and aperture sources, leading to solution speed acceleration between one and two orders of magnitude versus space-domain superposition of Hertzian dipole fields. To overcome the instabilities, prior to numerical evaluation one analytically identifies and merges all exponentially rising and decaying terms, yielding an overall well-convergent and stable solution process. We present numerical results concerning sensors used to detect marine hydrocarbon reserves.

14:40 *Microwave Imaging of Composite Materials Using Image Processing*

Azadeh Noori Hoshyar (Institute for Infrastructure Engineering, University of Western Sydney, Australia); Sergey Kharkovsky (University of Western Sydney & UWS, Australia); Bijan Samali (Institute for Infrastructure Engineering, Western Sydney University, Australia)

This paper presents the results of application of a relatively simple microwave continuous wave reflectometer with an open-ended waveguide antenna for the purpose of nondestructive testing and evaluation of composite materials using their images. It is shown that when the resulting original images could not reveal a desired amount of information about the interior of the sample under investigation, using the proposed image processing techniques can improve the results in particular as it relates to detecting the targets located at different depths. This paper presents the results of this investigation and a discussion of these results.

15:00 *Source Reconstruction From Near Field Scan Data of Stripline Structures*
Wolfgang Hauser and Manfred Albach (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)
Inverse problems have always been a major subject in engineering science. There are still no standard solution algorithms working reliably without adding considerable amount of expert knowledge. This class of problems is often described by integral equations. These equations can be interpreted as a convolution of a source with the pulse response of a linear time invariant system. This suggests that it is possible to solve them in spectral domain. As reconstructing the sources of a near field scan data constitutes an inverse problem, the aim of this paper is to show an algorithm to determine an approximate solution. This involves the usage of the spatial Fourier transform and the corresponding impulse response functions in spectral domain.

S2.7: Phased arrays and smart antennas

Room: Tasman B

Chairs: Ronghong Jin (Shanghai Jiao Tong University, P.R. China), Randy Haupt (Colorado School of Mines, USA)

13:00 *Optimum Tilt of a Phased Array Antenna for Elevation Scan*
Randy Haupt (Colorado School of Mines, USA)
Radars and communications systems must maintain contact with satellites in their orbits. The tilt angle and the maximum scan angle of a planar phased array are important factors in establishing the link budget. Previous studies derive an optimum tilt angle based on the element spacing and number of elements. This paper includes the satellite orbit and differentiates between a communications system and radar when finding the optimum tilt angle of a phased array.

13:20 *Superconducting Linear Phase Shifter for the Phased Array Antenna*
Hiroyuki Kayano (Toshiba Corporation, Japan)
We propose a continuous variable phase shifter as a new use of a tunable filter. To obtain a large phase shift, the filter is designed using the ideal transform function of the generalized Chebyshev function with real zero. The generalized Chebyshev function with real zero is realized by 4 resonators and jump coupling between resonators. The phase shifter tuned the center frequency by 4 dielectric rods with a piezoelectric actuator. The resonator uses a step-impedance hairpin microstrip line resonator. The phase shifter uses high-Tc superconducting material, YBCO. Therefore, this tunable filter had a low insertion loss of 0.3dB and constant magnitude. In addition, it showed linear phase change continuously. A maximum tuning phase was 372 degrees in condition of a maximum tuning speed of 2.66 msec.

13:40 *A Dual Polarized Suspended Stripline Fed Open-Ended Waveguide Antenna Subarray for Phased Arrays*
Narihiro Nakamoto (Mitsubishi Electric Corporation & Information Technology R&D Center, Japan); Toru Takahashi, Araki Ono, Masao Nakashima, Masataka Ohtsuka and Hiroaki Miyashita (Mitsubishi Electric Corporation, Japan)
This paper presents the design and experiment of an antenna subarray for wideband and dual linear polarized phased arrays. The proposed antenna is a one-dimensional linear array which consists of two feeding networks for each polarization and radiating elements. The suspended stripline is used as the transmission line of the feeding network because of its low loss. The radiating element is an open-ended square waveguide antenna with a parasitic element inside and a transition from waveguide to two orthogonal suspended strip feed lines. In order to achieve a good transition performance for both polarizations, the double ridged and quadruply ridged waveguides are combined in the transition. The prototype subarrays with ten radiating elements have been fabricated and measured in 16 element array. The experimental results show a good impedance bandwidth of 18%, low cross polarization levels less than −27 dB, and low losses with antenna efficiency above 70% in the frequency band of 14%.

14:00 *Limited Area Communication Using Sum & Differential Patterns*
Mitoshi Fujimoto, Kenji Takemoto and Toshikazu Hori (University of Fukui, Japan)
In this paper, a novel communication system for limited area communication is proposed. In the proposed system sum pattern and differential pattern is used. A main beam of the sum pattern is directed to the direction of the desired user and signal for communication is transmitted using the main beam. On the other hand, a null of the differential pattern is also directed to the desired user and a jamming signal is transmitted using the differential pattern. Numerical results show that the communication area is limited by interference due to the jamming signal while the communication distance is not affected.

14:20 *Multi-beam Massive MIMO Using Analog Beamforming and DBF Based Blind Algorithm*
Kentaro Nishimori (Niigata University, Japan); Takefumi Hiraguri (Nippon Institute of Technology, Japan); Tomohiro Seki (Nihon University, Japan); Hiroyoshi Yamada (Niigata University, Japan)
Massive MIMO enables the improvement on the transmission rate without increasing the burden on the signal processing by employing a large number of antennas at a base station (BS). Channel state information (CSI) feedback scheme from terminal stations to BS gives a very large overhead when considering massive MIMO and implicit beamforming (IBF) with the calibration technique as the countermeasures are introduced. However, it is reported that CSI estimation itself has a large overhead when considering massive MIMO. In this paper, we propose analog-digital hybrid configuration using analog multi-beams with dielectric line array and lens and blind algorithm called Constant Modulus Algorithm (CMA) which does not need the CSI estimation. Via a computer simulation, the effectiveness of proposed configuration is verified.

14:40 *Direction Finding and Calibration Method Based on Time Modulated Array*
Chong He and Ronghong Jin (Shanghai Jiao Tong University, P.R. China); Xianling Liang and Junping Geng (Shanghai Jiaotong University, P.R. China); Jingfeng Chen (Shanghai Jiao Tong University, P.R. China)
The applications of the time modulate array (TMA) in the direction finding and the array calibration are discussed. First, the fundamental idea to implement the direction-of-arrival (DOA) by the TMA is analyzed. Second, the parallel and fast array calibration method by the time modulation is introduced. Last, the paper is summarized, and some further research about the applications of the TMA in the dirction finding of coherent sources and the blind calibration is discussed.

15:00 *A Compact Beam Steering Planar Array with Broadband and High Gain*
Xuexia Yang, Luqi Di, Ying Shen and Jifu Huang (Shanghai University, P.R. China)
A broadband beam steering continuous transverse stub planar array fed by the parabolic reflector of substrate integrated waveguide (SIW) is proposed in this paper. The beam steering function could be realized by mechanically moving the H-plane SIW horn straightly along the direction of the stub. A 16-element array is simulated to validate the design. The simulation results show that the relative bandwidth of the reflection coefficient less than -10dB is 16.6% (12.18GHz-14.34GHz) with the center frequency of 13.0GHz. The gain at the broadside is 27.94dB with the first sidelobe level of -22.8dB and the 3dB beam width of 7.2°. Within the scanning angle of ±33° range, the gain decrease less than 3dB. This beam steering array has the good feature of broadband, high gain, simple and compact structure, and low cost. It could be applied in Ku band and millimeter wave bands.

S3.7: Antennas for 4G/5G applications

Room: Tasman C

Chairs: Chi Hou Chan (City University of Hong Kong, Hong Kong), Qing-Xin Chu (South China University of Technology, P.R. China)

13:00 *Three Principles of Designing Base-Station Antennas*
Qing-Xin Chu, Yu Luo and Ding-Liang Wen (South China University of Technology, P.R. China)
In this paper, researches on base-station antennas by our group in recent years are presented. Three principles of designing base-station antennas are proposed: wide band impedance match, stable radiation patterns in wide frequency band and high cross polarization ratio in wide angle range. According to the principles, a series of antennas have been designed, fabricated and measured. These base-station antennas have high performance such as wideband impedance matching, stable radiation patterns and high XPD in wide angle range

13:20 *Joint Mutual Coupling Characterization and Swarm Optimization for Efficient Base Station Antenna Beamforming*
Doudou Samb, Shi Lei, Zhonglin Wu and MuLin Liu (Tongyu Communication Inc., P.R. China)
In this work, practical beamforming technique is proposed for improving directional radiation properties of base station antennas operating at 1710-2690MHz. Firstly, we characterize the mutual coupling between antenna elements using Rohde & Schwartz multi-ports network analyzer. And with the active radiation parameters (from High Frequency Simulation Software), the real excitation coefficients of the different array elements' field are outputted by developing a MATLAB algorithm. Next, we use these excitation coefficients as inputs and then develop a swarm algorithm to compute the optimum phases of the array elements for a given sidelobes level requirement and beam steered angle. Experimental results are provided to confirm the analytical approach and the advantage of using mutual coupling characterization and swarm technique in base station antenna design process. Interestingly, results show that the analytical model approach can help to predict even the statistical performances of the antenna before testing it as minimum gap between analytical and experiment results has been observed.

13:40 *High Frequency and High Gain Two-Element Collinear Antenna Array*
Quan Xue and Shaowei Liao (City University of Hong Kong, Hong Kong)
This paper presents a new collinear antenna array that can realize high omnidirectional gain at 30GHz band. The array are formed by two stacked biconical antenna elements fed parallel through a balun, and each element can produce an omnidirectional gain of around 9.5dBi. The measured -10-dB impedance bandwidth of the antenna is 26.2-30.2GHz. Within the bandwidth, the antenna achieves a high measured omnidirectional gain of around 12.5dBi corresponding to about 5° 3-dB beamwidth.

14:00 *Element Design for Dual Circularly Polarized Reflectarrays with Dual Linearly Polarized Feed*
Geng-Bo Wu (UESTC, P.R. China); Shi-Wei Qu (University of Electronic Science and Technology of China, P.R. China); Chi Hou Chan (City University of Hong Kong, Hong Kong)
In this paper,a novel single-layer broadband subwavelength multi-resonance element is proposed to design a dual circularly polarized (CP) reflectarray with a dual linearly polarized (LP) feed. The simulated results show an adequate phase range over 360 and low mutual coupling between orthogonal field components of the element. Also, a superior bandwidth performance has been verified, compared to conventional cross-dipole element.

14:20 *Initial Measured OTA Throughput of 4G LTE Communication to Cars with Roof-Mounted Antennas in 2D Random-LOS*
Madeleine Schilliger Kildal (Chalmers University of Technology & Bluetest AB, Sweden); John Kvarnstrand (Bluetest AB, Sweden); Jan Carlsson (SP Technical Research Institute of Sweden, Sweden); Andrés Alayon Glazunov (Chalmers University of Technology, Sweden); Amir Majidzadeh (Volvo Car Corporation, Sweden); Per-Simon Kildal (Chalmers University of Technology, Sweden)
We present initial Over-The-Air (OTA) throughput measurements of an LTE device in a Volvo XC90 car with roof-mounted antennas. The measurements were performed in a semi-anechoic chamber and only in the horizontal plane. The throughput results are presented as a probability of detection (PoD) in 2D Random Line-Of-Sight (Random-LOS) with fixed polarization of the antenna at the base station side. Two car-mounted antennas were measured: a wideband two-port shark-fin type antenna in SISO and SIMO receive diversity-mode, and a narrowband monopole antenna. The PoD curves clearly show the expected performance improvements due to the antenna diversity. In addition, the Random-LOS measurements made it possible to discover potential for improvements of the tested antennas.

14:40 *A 28 GHz FR-4 Compatible Phased Array Antenna for 5G Mobile Phone Applications*
Naser Ojaroudiparchin and Ming Shen (Faculty of Engineering and Science, Aalborg University, Denmark); Gert Pedersen (Aalborg University, Denmark)
The design of a 28 GHz phased array antenna for future fifth generation (5G) mobile-phone applications has been presented in this paper. The proposed antenna can be implemented using low cost FR-4 substrates, while maintaining good performance in terms of gain and efficiency. This is achieved by employing a new air-filled slot-loop structure as the radiator. A prototype array consisting of ten radiator elements has been designed for concept validation. Both the radiation and total efficiencies of the antenna array are higher than -0.5 dB (90%) for the scanning range between 0o to 50o, while the gains are higher than 13 dB. In addition, the simulated and experimental results show that the antenna has the S11 response less than -10 dB in the frequency range of 27 to 29 GHz.

15:00 *Low Cost 3D-printed Monopole Fluid Antenna*
Kin-Fai Tong (University College London, United Kingdom); Cristina Borda Fortuny (UCL, United Kingdom); Jingyi Bai (UCL, University of London, United Kingdom)
Low cost 3D printed monopole fluid antenna is investigated. The PDMS container of the seawater is fabricated by 3D printing technology for reducing cost and complexity. The design parameters of the antenna have been studied for efficiency improvement. The achieved peak efficiency is about 70% at 2.75 GHz, and the impedance bandwidth is about 67%. Stable radiation patterns are demonstrated across the operating bandwidth. The radiation mechanism of the antenna has been explained.

S4.7: Miniaturized antennas for communications

Room: Wellington
Chairs: Shuxi Gong (National Laboratory of Antennas and Microwave Technology, P.R. China), Ying Liu (Xidian University, P.R. China)

13:00 *A Compact Polyhedron Dipole Antenna for Multi-Band Mobile Communication*
Hyunsoo Kim and Seungjae Lee (HCT, Korea); Muhammad Kamran Khattak (Incheon National University & Ghulam Ishaq Khan Institute of Technology, Korea); Sungtek Kahng (University of Incheon, Korea)
In this paper, we present a new compact antenna with multi-band characteristics for mobile communication. The antenna structure has a polyhedron shape as a 3D geometry. It is a modified dipole structure to have cooperatively coupled resonant current paths printed on both the sides of an FR-4 substrate. The basic design is carried out by a 3D electromagnetic simulating software and the multi-band antenna performance is verified by the fabrication and measurement.

13:20 *Dual-band Composite Broadband Absorbing Material Based on Frequency Selective Surface*
Wen Jiang and Mao Long (Xidian University, P.R. China); Bochao Yang (Xi'an Research Institute of Navigation Technology, P.R. China); Tao Hong and Shuxi Gong (Xidian University, P.R. China)
In this paper, A multi-layered composite wideband absorbing material covering dual band is designed and fabricated. The upper layer is a traditional absorber while the lower one is a dual-frequency frequency selective surface layer formed by a square ring and an improved Jerusalem cross structure. The absorbing band has been broadened obviously compared with those of the traditional absorber without frequency selective surface. The absorbing bandwidth has been broadened from 66% to 112%, within which the reflectivity is lower than -10 dB level in a frequency range of 3.9-13.75GHz. With the advantage of wide absorption band, the absorbing material covering C and X bands can be implemented in mobile communications, environmental protection, absorption of electromagnetic wave shielding, and physical protection.

13:40 *Reduction of Head Effect in Mobile Devices*
Hongkoo Lee and Jihwan Jeon (Hanyang University, Korea); Hyung-Hoon Kim (Kwangju Women's University, Korea); Hyeongdong Kim (Hanyang University, Korea)
This paper compares two types of antennas for Bluetooth applications in mobile handsets in the presence and absence of a human head. A Planar Inverted F Antenna (PIFA) and a three dimensional ground radiation antenna (GradiANT) were designed to fully cover Bluetooth services. The antennas are designed on a Frame Retardant Type 4 (FR-4) substrate ($\varepsilon r = 4.4$, $\tan \delta = 0.02$) with the size of 140 mm 45 mm Printed Circuit Board (PCB) with 1 mm thickness.

14:00 *Printed Monopole Slot Antenna for WWAN Metal-Rimmed Smartphone Applications*
Yong-Ling Ban, Yan-Li Yang, Ming-Yang Li and Li-Wan Zhang (University of Electronic Science and Technology of China, P.R. China); Hanyang Wang (Huawei Technologies, United Kingdom)
A printed L-shaped slot antenna for WWAN metal-rimmed smartphone applications is presented in the paper. Embellished by the metal rim, the modern smartphones have achieved enhanced mechanic strengthen as well as better cosmetic appearance. However, the only problem should be addressed on the resonance disorder introduced by the metal rim. Although it has been partially solved by etching slits and adding grounded patches, yet the metal rim resonances are not fully utilized which results in large size consumption. In the proposed scheme, the resonances generated by the metal rim are better exploited to further reduce the antenna size. Four resonant modes are generated by the disjoint metal rim and double L-shaped slots to cover the WWAN band operation. With small size occupation and wide band coverage, the proposed antenna is a promising candidate for the metal-rimmed smartphone applications.

14:20 *A Dual-band Slot Quasi-Yagi Antenna with Very Low Profile*
Liu Hu, Ying Liu and Shuxi Gong (Xidian University, P.R. China)
A novel dual-band slot Quasi-yagi antenna with an extremely low profile for WLAN and WiMAX communication systems has been proposed. The antenna is designed with multilayered structure. The traditional slot antennas printed on the PCBs are applied to be the antenna elements of the proposed quasi-yagi antenna. A long-slot mode and a short-slot mode are generated simultaneously to give the antenna dual-band property. An extremely low profile of 0.097λ and 0.14λ has been obtained at 2.4GHz and 3.5GHz, respectively. Meanwhile good end-fire radiation patterns and relatively high gain of 8.14dB and 9.43dB at the two frequencies have been obtained.

S5.7: Multiband and wideband antennas, and emerging antenna technologies

Room: Auditorium

Chairs: Hisao Iwasaki (Shibaura Institute of Technology, Japan), Hisamatsu Nakano (Hosei University, Japan)

13:00 *Hyper-Wideband Four-arm Antenna*

Hisamatsu Nakano, Masaki Takeuchi and Junji Yamauchi (Hosei University, Japan)

An antenna, composed of low-profile four arms, is investigated. The analysis shows that bending the arms makes the VSWR value small at low frequencies. It also shows that the meandering cells introduced to each arm contribute to a decrease in the lower band-edge frequency. Thus, the investigated antenna operates across a frequency region of 2.88 GHz to 50 GHz for a VSWR = 2 criterion. The radiation pattern and gain are also investigated.

13:20 *A Grid Array Antenna with Parasitic Monopoles*

Toru Kawano (National Defense Academy, Japan); Hisamatsu Nakano (Hosei University, Japan)

A system composed of a grid array antenna (GAA) and parasitic monopoles is analyzed. The analysis is performed using an integral equation with the method of moments to reveal the radiation pattern, axial ratio, half-power beam-width and gain. It is found that the parasitic monopoles contribute to transforming a linearly polarized beam from the GAA into a circularly polarized beam. It is also noted that this circularly polarized beam is almost symmetric with respect to the antenna axis normal to the GAA.

13:40 *Evaluation Related to Finger Position and Rotation of Wearable Dual Band Inverted-F Finger Ring Antenna*

Naohiro Noda (Graduate School of Engineering and Science Shibaura Institute of Technology, Saitama, Japan); Hisao Iwasaki (Shibaura Institute of Technology, Japan)

BAN antenna can be wearing on finger is desirable. So, wearable antennas for applicable to finger ring size were proposed by authors. These antennas were dual band use for UWB band (7.25-10.25 GHz) and ISM band (2.4 -2.5 GHz). And, these antennas were made of fabric cloth. In this paper, we discuss the wearable dual band antenna made of conductor such as finger ring to transmit monitoring information of temperature, pulse and heart beat from sensors to finger ring antenna for WMTS band (915-930 MHz) and to transmit information from the finger ring antenna to outside network by using WiFi or wireless LAN for ISM band. Details of the simulated VSWR results and evaluation related to finger position shift and rotation of the proposed antenna are presented. VSWR less than 2 at ISM band and WMTS band was obtained when the proposed antenna was mounted on finger. The influence of antenna rotation and position shift are clear.

14:00 *A Wideband MIMO Antenna Using Leaf-Shaped Monopole and Notch Antennas*

Manabu Yamamoto and Shohei Maeda (Hokkaido University, Japan)

This paper presents a design of a wideband 4-port antenna array being useful for MIMO applications. In the designed antenna array that operates over the frequency band of 7.25-10.25GHz, a leaf-shaped monopole and notch antennas are employed as the array elements. By using these orthogonal polarization elements, both low coupling level between adjacent array elements and miniaturization of the antenna structure are realized. In order to demonstrate the effective performance of the presented configuration, characteristics of the designed MIMO antenna are evaluated by the finite-difference time domain (FDTD) analysis. Over the above-mentioned frequency band, the designed antenna has the reflection coefficient of less than -10 dB and the mutual coupling between ports below -12 dB. In addition, the antenna port envelope correlation coefficient is observed to be less than 0.22.

14:20 *High-Gain Wideband Circularly Polarized Resonant Cavity Antenna*

Huy Hung Tran and Ikmo Park (Ajou University, Korea)

This paper presents a high gain wideband circularly polarized (CP) resonant cavity antenna. The primary radiators consist of two orthogonal bowtie dipoles, which generate wideband CP radiation. High-gain broadside radiation and wide axial ratio (AR) bandwidth are achieved with the properly chosen lateral size of a half-wavelength-thick planar partially reflecting surface. The antenna with an overall size of 80 mm × 80 mm × 28.35 mm yields -10-dB impedance, 3-dB AR, and 3-dB gain bandwidths of 40%, 25.6%, and 42.7%, respectively.

14:40 *Effectiveness of a Dipole Feeder for the Cross Spiral Antenna Which is a Circularly and Linearly Polarized Planar Antenna*

Mayumi Matsunaga (Ehime University, Japan)

A novel feeding way for balanced antennas, loop antennas and spiral antennas, is presented. The author invented recently a circularly polarized simple loop antenna, CSA, which is configured only by twisting a loop like a cross shape. The CSA can radiate good circular polarization, if it is fed by a good balanced feeder. The strict balance of currents is needed that CSA radiates good CP waves, so a feeder that can neutralize unbalanced currents of a poor balanced feeder is necessary. In this paper, a dipole element is employed to feed CSA. To show the effectiveness of the dipole feeder, the S11 characteristics and radiation patters obtained by feeding CSA with a coaxial cable are compared with those obtained by feeding CSA with a balanced feeder. These results show that the dipole feeder is useful to neutralize unbalanced currents.

15:00 *A Millimeter-wave Antenna with Wideband Mode-transition Between Microstrip-line and Waveguide*

Ryohei Hosono (Fujikura, Ltd., Japan); Yusuke Uemichi and Xu Han (Fujikura Ltd., Japan); Yusuke Nakatani and Ning Guan (Fujikura, Ltd., Japan)

A millimeter-wave antenna directly fed by waveguide is proposed. The antenna has a simple dipole element fed by a microstrip-line (MSL) which is connected to WR-15 waveguide via a wideband mode-transition. The aperture is attached by a metal two-staged aperture which is connected to the waveguide and it provides a wideband mode-transition with bandwidth of 16.7% (55-65 GHz). A bow-tie-shaped dipole antenna is combined with the mode-transition and an impedance bandwidth of 18% (58-69.5 GHz) is realized. The antenna shows a broad-beam radiation pattern and can be used in short-range wireless communication for 60 GHz-band applications.

15:40 - 18:00

S1.8: Microwave imaging for biomedical and other applications II

Room: Tasman A

Chairs: Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia), Yoshihiko Kuwahara (Shizuoka University, Japan)

15:40 *Microwave Mammography with a Small Sensor*

Yoshihiko Kuwahara and Naoyuki Ozawa (Shizuoka University, Japan)

In this paper, we propose a microwave mammography system with a small sensor. This system has features as follows, (a) a structure of aspirating and fixing patient's breast to prevent imaging mistakes and to offer an important prior knowledge of breast shape, (b) the polarization diversity of microwave to downsize the imaging sensor and ensuring the variety of observations, (c) commercial electro-magnetic (EM) simulator for the forward solver to reduce the modeling error. We have carried out some numerical simulations to confirm the effectiveness of the proposed system.

16:00 *Three-Dimensional Near-Field Microwave Imaging Approach Based on Compressed Sensing*

Yang Fang, Baoping Wang and Chao Sun (Northwestern Polytechnical University, P.R. China)

Considering the difficulties in big data processing and low imaging resolution of traditional near-field microwave imaging approach, a new near-field imaging approach based on compressed sensing is proposed in this paper. Under the premise of discretization of imaging scene, the approach adopts sparse observation to reduce the sample data volume and improve imaging efficiency; and uses the optimization reconstruction algorithm to obtain the target image and improve the imaging resolution. The effectiveness of this approach is verified through simulation experiment and real test experiment. The results show that, compared with the traditional imaging result, the proposed approach in this paper is of higher resolution, even if with a small amount of data.

16:20 *Electro-Biomechanical Breast Phantom for Hybrid Breast Imaging*

Bassem Henin, Amin Abbosh and Wael Al Abdulla (The University of Queensland, Australia)

The fabrication of an electro-biomechanical breast phantom for testing microwave-mechanical hybrid systems designed for breast imaging is presented. The presented breast phantom is designed to emulate both the electrical and mechanical properties of the human breast tissues. A material that has electrical and mechanical properties equal to those of the soft human breast tissues is manufactured using simple low-cost substances. The measured electrical and mechanical properties of the phantom are in good agreement with the properties of the real breast tissues. The presented phantom is vital for validating strain imaging techniques that relies on the contrast in both of the dielectric and mechanical properties between the healthy and cancerous breast tissues.

16:40 *Planar Microstrip Antenna Array for Hybrid Electro-Biomechanical Breast Imaging*

Bassem Henin (University of Queensland, Australia); Amin Abbosh (The University of Queensland, Australia)

The design of a compact wideband antenna array for use in microwave-mechanical hybrid system aimed at the early detection of breast cancer is presented. The proposed array uses probe-fed planar circular-shaped patch antennas placed on a movable plate. The elements of the antenna array are used to transmit a wideband pulse towards the breast and measure the backscattered pulse before and after compressing the breast by a controlled force applied at the top of the movable plate. To improve the bandwidth of the antenna array, each element of the array uses curved slots located on both the patch and the ground plane, and an annular ring around the circular patch. The presented performance of the antenna indicates wideband operation across the band from 2.4 GHz to 3.9 GHz

17:00 *Matching Medium for Biomedical Microwave Imaging*

Hoi-Shun Lui (The University of Queensland, Australia); Andreas Fhager and Mikael Persson (Chalmers University of Technology, Sweden)

The choice of matching medium in microwave imaging for biomedical applications is studied. A multi-layer planar human tissue is first used to investigate the amount electromagnetic wave is transmitted through the tissue model using different matching medium. This will give us further insights on wave propagation through human tissue, which assists us to determine to choice of matching medium. As an example, image reconstruction of simplified human breast model with different matching medium using an inverse scattering algorithm will be used to verify our findings.

17:20 *Comparison Study of Microwave Patch Antennas At 434 MHz for Intra Cavitary Hyperthermia Applicator Design*

Tharrini Rajendran and Kavitha Arunachalam (Indian Institute of Technology Madras, India)

Targeted heating with minimal dose to neighboring tissues is possible with intra cavitary microwave applicators as they can treat tumors within/or nearby body cavities. Here we present an intra cavitary applicator for hyperthermia treatment of gynecological cancers at 434 MHz. A 3D numerical model of the applicator with conformal patch antenna in muscle tissue is studied for rectangular patch, variations of bow tie and spiral antennas. Antenna performance is evaluated in terms of size, return loss, bandwidth, specific absorption rate (SAR) and effective field surface (EFS). Fish tailed bow tie and spiral patches exhibited <-25 dB return loss and >25 MHz bandwidth compared to other shapes. EFS of spiral antenna is larger than fish tail. However, ratio of EFS to patch area indicates larger volumetric power deposition for fish tailed bow tie. From simulation results, it can be concluded that an array of fish tailed bow tie and/or spiral patch antennas would provide adjustable heating profile with high power deposition.

17:40 *Microwave Tomography Using DBIM with Double Mesh Scheme*
Latifah Mohamed (Universiti Malaysia Perlis, Malaysia); Yoshihiko Kuwahara (Shizuoka University, Japan)
It is necessary to assure the accuracy of forward calculation with high resolution to acquire accurate image reconstruction. For the forward calculation to be accurate, a fine mesh is used which will accurately determine the electric field everywhere in imaging region. However, due to limited number of measurements can be achieved for any realistic lab-scale system, a coarse mesh with less unknown parameters is required to avoid limited illness and thus can reduce the calculation cost in inverse problem. In this paper, a double mesh scheme in image reconstruction stage is introduced to detect small objects while decreasing calculation cost and assuring the accuracy of the forward calculation.

S2.8: Diversity antennas, MIMO antennas and systems

Room: Tasman B

Chairs: Wu Qun (Harbin Institute of Technology, P.R. China), Kumarasamy Somasundaram Senthilkumar (PNG University of Technology, Papua New Guinea)

15:40 *MIMO Array for Space Division Duplex*
Kentaro Murata and Hisashi Morishita (National Defense Academy, Japan); Naoki Honma (Iwate University, Japan)
We propose a novel self-interference cancellation (SIC) technique for space-division-duplex (SDD) multiple-input multiple-output (MIMO) array. The proposed SIC approach is as follows; first, an one-rank channel matrix, called a SI matrix in the paper, having only one dominant mode is formed between multiple transmitting (Tx) and receiving (Rx) antennas in a same SDD array. Then, the Tx/Rx ports are spatially isolated by cutting off the dominant mode giving eigenweight excitation to either the Tx or Rx array, that is, SIC is achieved at a cost of only one degree of freedom (DOF). For this SIC approach, we present a simple analog implementation using a cuboidal array configuration for the one-rank SI matrix and hybrid couplers for the eigenweight excitation. In this paper, theoretical aspects of the proposed technique are mainly focused on, and some numerical results are given demonstrating a good SIC effect even in some practical models.

16:00 *Investigation of Polarization Deficiencies in SIMO Systems in Random-LOS Propagation Channels*
Aidin Razavi, Andrés Alayon Glazunov, Per-Simon Kildal and Jian Yang (Chalmers University of Technology, Sweden)
We study the probability of detecting one and two bitstreams of a 2x2 polarization-MIMO system with co-located orthogonally polarized antenna ports on both sides of a free-space propagation environment with arbitrary angle of arrival, i.e., in so-called Random-Line-Of-Sight (Random-LOS) propagation environments. We show that the system performance is better for when one side of the link is circularly polarized and the other linearly polarized, in particular for the single bitstream case. We also show that the two-bitstream case is more sensitive to polarization deficiencies on the receiving side than the single-bitstream case is. Polarization deficiencies appears in symmetry planes if the E-and H-plane patterns of each of the two receiving ports are different, and in the diagonal plane if the far-fields of the two ports are non-orthogonal there.

16:20 *Basic Performance of Massive MIMO in Indoor Scenario At 20-GHz Band*
Rryochi Kataoka and Kentaro Nishimori (Niigata University, Japan); Ngochao Tran and Tetsuro Imai (NTT DOCOMO, INC., Japan)
Massive multiple input multiple output (MIMO) enables the improvement on the transmission rate without increasing the burden on the signal processing by employing a large number of antennas at a base station. It was reported an effect of applying a massive MIMO to small cell at the 2-GHz band. However, main target of the massive MIMO will be the small cells at the high-frequency band, because the antenna size is very large when considering the massive MIMO in macro frequency band. In this paper, real propagation channels are measured by using a wideband channel sounder with horn antenna in 20-GHz band in an actual indoor propagation environment. Moreover, the performance of the interference rejection is evaluated when virtual circular array antenna with 24 elements is assumed.

16:40 *Combination Benefits of Short-Time Diversity and Adaptive Satellite Power Control*
Peeramed Chodkaveekityada and Hajime Fukuchi (Tokyo Metropolitan University, Japan)
The next generation of satellite will be operated in the higher frequency bands. Rain attenuation will become in front to degrade the satellite signal. In this paper, time diversity method and adaptive satellite power control method are combined in order to mitigate the rain attenuation by using rain radar data over Japan. However, due to the effectiveness of time diversity method and small behaviors of rain in Japan, a short time delays and a few power boost beam are evaluated. The performance of the system presents by the diversity gain, and these two systems are compatible well.

17:00 *Application of Perceptron Model for Adaptive Beamforming in Array Antennas*
Kumarasamy Somasundaram Senthilkumar (PNG University of Technology, Papua New Guinea); Kandasamy Pirapaharan and Paul Hoole (Papua New Guinea University of Technology, Papua New Guinea)
In this paper, a single neuron neural network beamformer is proposed. A perceptron model is designed to optimize the weights of a dipole array antenna to steer the beam to desired directions. The objective is to reduce the complexity by using a single neuron neural network and utilized it for adaptive beamforming in dipole array antennas. The optimized coefficients calculated from the single neuron neural network are compared with the coefficients optimized from the traditional Least Mean Square (LMS) method. Matlab is used to optimize the weights in neural network and LMS method as well as display the comparison in graphical format.

17:20 *THP Based on Cholesky Factorization with Unitary Transformation for Multiuser MIMO*

Satoshi Denno and Tatsuya Itakura (Okayama University, Japan)

This paper proposes two types of Tomlinson-Harashima precoding (THP) based on Cholesky factorization for multiuser MIMO systems where the receiver has at least two antennas. In the system with the THP, a linear filter is introduced for the receiver. The performance of the proposed THP is evaluated by computer simulation. As a result, it is shown hat the BER performance of the THP is much superior to that of the conventional THP.

17:40 *Accurate Design of High-Performance Diplexers for Mobile Communication Base Stations Applications*

Dawei Zhang and Xumin Ding (Harbin Institute of Technology, P.R. China); Baofu Jia and Bin Yu (University of Electronic Science and Technology of China, P.R. China); Wu Qun (Harbin Institute of Technology, P.R. China)

This work describes a modified approach for extracting the equivalent circuit parameters, as there are the resonant frequency of each resonator, the coupling bandwidths and the external Qs from multi-port Y-matrix and group delay of the input reflection coefficients. The extractions of equivalent circuit parameters and the fine tuning for three-dimensional simulating models are achieved by utilizing the EM simulating software HFSS. Then, a novel method for designing microwave diplexers is proposed. Compared to the methods existed, all interacting effects are allowed taking into account. One circuit parameter can be related to one dominate geometrical variation in the three-dimensional model. The detailed design steps illustrating the design of a diplexer for mobile communication base stations applications are presented. The designed device with a novel tunable electrical coupling structure is then fabricated. The comparison between measurements and simulations has validated the new design method with high efficiency.

S3.8: Antenna measurements I

Room: Tasman C

Chairs: Oleksiy S. Kim (Technical University of Denmark, Denmark), Christian Lötbäck (Bluetest AB, Sweden)

15:40 *Extending the Bandwidth of a Superdirective First-Order Probe for Spherical Near-Field Antenna Measurements*

Oleksiy S. Kim (Technical University of Denmark, Denmark)

A superdirective array of electrically small dipole radiators can effectively be used as a compact and lightweight first-order probe (a directive antenna radiating predominantly spherical modes with the azimuthal index $|\mu| = 1$) in spherical near-field antenna measurements at low frequencies. This contribution shows that a very narrow frequency bandwidth peculiar to superdirective antennas can be extended to practical values by the proper design of the array elements as well as by relaxing the maximum directivity condition, while keeping $|\mu| = 1$ modes dominating in the radiation spectrum of the antenna. The resulting probe has the relative bandwidth of 3% and directivity above 9 dBi; its height is 0.5λ over a 1λ circular ground plane.

16:00 *Improved Cavity Perturbation Technique for Accurate Measurement of Complex Permittivity*

Chulki Kim and Byeong-Yong Park (KAIST, Korea); Seong-Ook Park (Korea Advanced Institute of Science and Technology, Korea)

Cavity perturbation method is traditionally simple and accurate technique to detect a material although completely a few techniques have been developed for the measurement. But there have the problems that is the change in the total geometric form of the electromagnetic fields inside the cavity resonator. Using a new cavity perturbation technique proposed in this paper, we calculate the complex permittivity of dielectric material. And then we more expanded the maximum volumes of the sample ratio to cavity resonator than the conventional cavity perturbation technique.

16:20 *Antenna Measurements in Reverberation Chambers and Their Relation to Monte Carlo Integration Methods*

Robert Rehammar, Anton Skårbratt and Christian Lötbäck (Bluetest AB, Sweden)

In this paper we point out the similarities between measurements performed in a reverberation chamber and the numerical method of Monte Carlo integration. Further, the corresponding measurements in anechoic chambers will be viewed as Riemann-type of integration. The insight that reverberation chamber measurements share many similarities with Monte Carlo integrations is not of pure academic interest. It opens up to utilize many of the methods developed in computational physics and statistics to speed up Monte Carlo integrations. Some of these techniques will be discussed here together with applications.

16:40 *Study of Near Field for WPT System*

Sangbong Jeon (ETRI, Korea)

In this paper, the near field distributions was measured using the PCB scanner to analyze the noise source of magnetic resonance wireless power transmission system. The measured sample is transmitted by magnetic resonance using 6.78 MHz. The main noise sources are generated a lot of the harmonics of 6.78 MHz resonance frequency and internal clock signal of regulator for supplying a stabilized power. The harmonic signal is shown to be widely distributed in frequency band.

17:00 ***Influence of Microstrip Probe Pad Design on Planar Measurements Using On-Wafer Probes***

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

This publication refers to work previously published by the authors at ISAP 2014. There, it has been shown how measurements with an on-wafer probe on planar transmission lines up to 67 GHz can be used for the determination of the transmission line's substrate permittivity. Especially the microstrip probe pad on the substrate, which represents the probe-microstrip interface, has shown to be of significant influence on the measurement data, which allowed measurements up to only 25 GHz. The work presented in this paper gives measurement data with a doubled frequency limit of 50 GHz. Additionally, different sources of interference such as coupling, higher modes and probe pad design are discussed. An example for a broadband transition from on-wafer probe to microstrip is shown, which can be used for on-wafer or PCB antenna measurements up to 200 GHz. Finally, design rules on how to avoid the deteriorating effect on measurement data are given.

17:20 ***Estimation of RF Leakage to Oncoming Train Cars From Wireless Access Point Operating in Bullet Train Passing Through a Tunnel***

Masami Shirafune, Takashi Hikage, Manabu Yamamoto and Toshio Nojima (Hokkaido University, Japan); Minoru Inomata (NTT Corporation, Japan); Motoharu Sasaki (NTT Access Network Service Systems Laboratories, Japan); Wataru Yamada (Nippon Telegraph and Telephone Cooporation, Japan); Takeshi Onizawa (NTT Corporation, Japan)

The aim of this study is to develop an accurate and reliable method of estimating field distributions in train cars so as to advance radio link design of wireless LANs operated inside the cars. This paper describes effects of absorption and shielding caused by a large number of passengers on propagation characteristics of RF leakage from wireless access point operating in a bullet train. Field distributions created by a 2.4 GHz-band wireless transmitter inside cars, when oncoming train cars are passing through a double track railway tunnel, are analyzed and propagation characteristics are determined from the analysis results.

17:40 ***Measurement of Dipole Antenna in Deionized Water***

Hiroyasu Sato (Tohoku University, Japan)

Ingestible capsule endoscope systems is expected for healthcare applications and high efficiency antenna for capsule endoscope is studied by many researchers. In order to evaluate an antenna characteristics inside the human body, it is necessary to evaluate both the input impedance of antennas and the transmission characteristics inside and outside of a human body. In this paper, measurement result of dipole antennas in deionized water is compared with numerical analysis. The results of FDTD simulation and measurement are shown good agreement. Maximum transmission coefficient of -25 dB through the 74 mm thick deionized water was obtained.

S4.8: Novel materials for RF devices

Room: Wellington

Chairs: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia), Mohamad Kamal A. Rahim (Universiti Teknologi Malaysia, Malaysia)

15:40 ***Nonreciprocal Graphene Magnetoplasmons: Latest Advances***

Nima Chamanara and Christophe Caloz (Ecole Polytechnique de Montreal, Canada)

We present an overview of graphene magnetoplasmonics and its latest advances. Novel magnetoplasmonic devices including a highly sensitive magnetic sensor based on coupled edge magnetoplasmons, and a graphene ferrite isolator based on the unique TE plasmonic mode of graphene are presented. The magnetic sensor may find application as magnetic reader in magnetic hard drives. The presented isolator is tunable, ultra wideband, and magnetless, and may find applications in terahertz circuits involving nonreciprocal elements.

16:00 ***A Highly Flexible and Efficient Dipole Antenna Realized in Methanol-Treated Conductive Polymers***

Shengjian Jammy Chen (The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia); Pejman Talemi (The University of Adelaide, Australia); Benjamin Chivers and Roderick Shepherd (The University of Sydney, Australia)

A highly flexible and efficient 2.45-GHz dipole antenna realized in methanol-treated conductive polymers PEDOT: PSS (PEDOT) is presented. The originally highly conductive PEDOT thin films have been further treated by immersion in a methanol solution, to realize a significant conductivity improvement from approximately 3500 S/m to 18500 S/m. As a result, a more than 25% antenna efficiency enhancement is attained, which brings the averaged efficiency up to 91.4% of the efficiency of a copper reference antenna with identical geometry. This simple treatment shows a practical and affordable solution to significantly improve conductivity for conductive polymers and make this type of materials even more suitable for antenna applications, particularly in conformal and flexible configurations. To verify the performance improvement, three identical antennas realized in copper, untreated and treated PEDOT have been fabricated and experimentally characterized. The results are in very good agreement with the full-wave simulations and confirm the expected improvement.

16:20 *Effect of a Flexible Polymer Dielectric and Magneto-Dielectric Composite Substrates in Antenna Array*

Abdulrahman Shueai Mohsen Alqadami (University Malaysia Perlis (UniMAP), Malaysia); Faizal Jamlos (Universiti Malaysia Perlis, Malaysia)

This paper presents a comparative study on the effect of the polymer dielectric and magneto-dielectric substrates in antenna array. A 1×2 multilayer antenna array based on polymer magneto-dielectric (PDMS-Fe3O4) composite substrate have been designed and fabricated to evaluate the contribution of such substrate materials in antenna array performance and characteristics. The proposed antenna was compared with another antenna fabricated on multilayer dielectric polydimethylsiloxane (PDMS) substrates which used as a reference antenna. Both antennas are operating at 5.8 GHz. The simulated and measured results of the proposed magneto-dielectric (PDMS-Fe3O4) antenna have shown an excellent enhancement in impedance bandwidth up to 1554 MHz (26.7%) compared to 470 MHz (8.1%) for a pure dielectric PDMS antenna that has the same substrate thickness. The gain and radiation efficiency of the magneto-dielectric based antenna is 7 dB and 60% respectively, which indicate a good and satisfactory of antenna's performance.

16:40 *Radio Frequency Performance and Strain Testing of an Iron-On Fabric Shielded Stripline*

Deshan Govender (University of Adelaide & Defense Science & Technology Organisation, Australia); Jon P Arnold (Defence Science and Technology Organisation & University of Adelaide, Australia); Wayne Martinsen (Colleague, Australia)

A shielded stripline structure made from commercially available fabric and fleece has been produced using iron- on fabrication techniques and its radio frequency performance evaluated over the range of 10 MHz to 7 GHz. Presented are the simulated and measured return loss and forward transmission characteristics. Also investigated are attachment techniques by which SMA connectors are bonded to the flexible shielded stripline. Four bonding techniques; three solder and one epoxy were evaluated by being subjected to precise mechanical loading. Copper laden solder provided the best bond strength.

17:00 *Connection Strategies for Wearable Microwave Transmission Lines and Antennas*

Sree Pramod Pinapati (University of Adelaide, Australia); Thomas Kaufmann (The University of Adelaide, Australia); Ian Linke (University of Adelaide, Australia); Damith C. Ranasinghe (The University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

In this paper a range of connection strategies are investigated for application to flexible passive microwave devices. The binding theme of all solutions is a simple manufacturing process and compatibility with textile materials. Three potential connection strategies are presented - snap-on buttons, butterfly clasps and wing solution. All the connection strategies are evaluated on a perpendicularly fed microstrip line. Based on the electrical performance, manufacturing complexity and mechanical stability, the best connection strategy is suggested for microwave applications in practical on-body environments.

17:20 *Plasmonic Ship-Wake on Graphene*

Xihang Shi and Baile Zhang (Nanyang Technological University, Singapore)

Kelvin predicted that the semi-angle of the V-shaped wedge behind a ship moving in deep water region is 19.5° , independent of the ship's velocity. The predication has been challenged recently that the semi-angle would transit from Kelvin angle to Mach angle as the ship's velocity increases. In this paper, we show the graphene plasmons excited by a swift charged particle would have the similar phenomenon. When the velocity of the charged particle is relatively slow, the graphene plasmons excited would pile up along the caustic boundary of the graphene plasmons pattern, forming the plasmonic Kelvin angle. At large velocity, however, no graphene plasmons would pile up along any boundary, thereby the caustics disappear and the effective semi-angle of the graphene plasmons approaches the Mach angle.

17:40 *Dual Resonance Circular Ring-Shaped Metamaterial Absorber with Wide Operating Angle*

Osman Bin Ayop, Mohamad Kamal A. Rahim, Noor Asniza Murad and Noor Asmawati Samsuri (Universiti Teknologi Malaysia, Malaysia)

This paper proposed a dual resonant circular ring-shaped metamaterial absorber (MMAbs) with wide operating angle in X-band frequency. The structure is constructed on FR4 substrate. The resonating elements are designed using two circular rings structure with different radius. The resonating elements are printed on the top surface of FR4 substrate, while at the bottom layer; a full copper layer is placed. The performance of the designed structure is observed using CST software. From the simulation, the proposed structure achieves high absorbance, which is 93.80% and 86.19% at 9 GHz and 11 GHz respectively for normal incident EM wave. Then, the structure is also simulated for oblique incident angles. It is observed that the operating angle of the proposed metamaterial absorber is 69o for both TE and TM polarization. The measurement is done to validate the simulated result.

S5.8: Radio wave propagation I

Room: Auditorium

Chairs: David V Thiel (Griffith University, Australia), Hideki Omote (Softbank Corp., Japan)

15:40 *Measurement of Time-Spatial Characteristics Between Indoor Spaces in Different LOS Buildings*

Hideki Omote (Softbank Corp., Japan); Masayuki Miyashita (SoftBank Corp., Japan); Ryo Yamaguchi (SOFTBANK Corp., Japan)

In order to overcome the increasing traffic problems of mobile terminals used in high-rise offices of buildings, it is necessary to clarify the time-spatial characteristics which are composed of the characteristics of the path loss, the delay profile and the spatial arrival angular profile for travelling waves from one high-rise office to another office in a different building. In this paper, we measure the time-spatial characteristics of radio waves passing from one indoor space to another and identify the key parameters determining the time-spatial characteristics based on measured results.

16:00 ***Measurements on FM Waves From Japan and Korea for Estimating Overreach Interference Sources of Terrestrial TV Waves***

Masahiro Nishi, Shotaro Taniyama, Koichi Shin and Teruaki Yoshida (Hiroshima City University, Japan)

In western Japan, the terrestrial digital TV waves have been sometimes affected by co-channel overreach interferences from Korea. To evaluate the co-channel interferences, we have proposed a new method monitoring both RSSI (Received Signal Strength Indicator) and CNR (Carrier to Noise power Ratio) of the digital TV waves and RSSI of FM broadcasting waves at the same time and we installed the measurement system at KIT (Kyushu Institute of Technology) in Fukuoka prefecture. At the measurement point, there are some candidates of overreach interference sources transmitting TV waves with same frequency, not only in Korea but also in Japan. In this study, we tried to estimate the overreach interference sources based on our proposed method monitoring FM waves transmitted from stations nearby the several candidates of interference sources. From the measurement results, it was found that the main overreach interference was from Korea, and that the main factor of the interference was an atmospheric duct propagation occurred over the sea.

16:20 ***An Efficient Amplitude Fluctuation Model for the Wave Propagation in Solar Corona Based on Rytov's First Iteration Method***

Guanjun Xu (Harbin Institute of Technology, P.R. China); Zhaohui Song (East China Normal University, P.R. China)

In this paper, a new numerical method based on Rytov's first iteration is implemented to analyze the amplitude fluctuation when the Electromagnetic (EM) waves pass through the solar corona during the superior solar conjunction. Integrated with approximated geometrical model of the deep space communication, the proposed amplitude fluctuation model incorporates both the solar wind density model and its irregularities spectrum model. In addition, the scintillation index model is further derived from the proposed model, which is normally used to characterize the amplitude fluctuation. Simulation results indicate that the proposed model can quantitatively evaluate the amplitude fluctuation under various scenarios. Besides, the derived scintillation index model achieves better accuracy compared with other models and the measurement data collected by the deep space probe. The good performance in terms of both efficiency and accuracy makes the proposed model be possible applied in forecast the amplitude fluctuation in the deep space communication.

16:40 ***ISM Band 2.45 GHz Propagation Studies in a Coastal Environment***

Nicholas Jackson and David V Thiel (Griffith University, Australia)

Over the past decade there have been significant advances in Wireless Sensor Networks creating a shift in the paradigm of information acquisition from a single highly expensive dedicated sensor to larger cheaper networked micro- systems. While research has been conducted into the performances of implemented sea surface Wireless Sensor Networks, little is known on how seawater affects the 2.45 GHz ISM frequencies. This paper discusses the propagation characteristics and subsequent signal path loss of low powered transceivers across a body of water.

17:00 ***Influences of Scattered Field Caused by Buildings to ILS Localizer in Airport***

Junichi Honda (Electronic Navigation Research Institute, Japan)

This paper is concerned with influences of scattered field caused by buildings to instrument landing system (ILS). The localizer (LOC) which is one of ILS, plays an important role to provide guidance in the horizontal position of aircraft. The LOC emits signals with a varying modulation. The performance of the LOC is obtained by the difference of depth of modulation (DDM) whose values are distorted by the multipath caused by scattering objects, such as building and aircraft. In this paper, we provide a solution for analyzing electromagnetic fields in airport. Firstly, we review the principle of the LOC system. Then, we propose a numerical method based on the ray tracing method (RTM) in three dimensional propagation environment. In the numerical simulation, we show field distribution and the value of DDM. Finally, we discuss the influences of scattered field caused by buildings in an airport.

17:20 ***Path Loss Characteristics Between Indoor Spaces in Different LOS Buildings***

Masayuki Miyashita (SoftBank Corp., Japan); Hideki Omote (Softbank Corp., Japan); Ryo Yamaguchi (SOFTBANK Corp., Japan)

In order to overcome the increasing traffic problems of mobile terminals used in high-rise floors of buildings, the three-dimensional cell configuration which places small cells on various floors is considered. In order to evaluate the wireless transmission technology for the three-dimensional cell configuration, it is necessary to clarify the time-spatial characteristics which encompass the characteristics of the path loss, the delay profile and the spatial arrival angular profile for waves travelling from one indoor space in a high-rise office to another such indoor space. In this paper, we measure the path loss characteristics of radio waves passing from one indoor space to another and identify the key parameters for the path loss characteristic based on measured results. Further, we compare measured and simulation (ray tracing) results. Finally, we use the simulation results to analyze the relation between the parameters and path loss characteristics.

17:40 ***S-band Radio Propagation Characteristics in Urban Environment for Unmanned Aircraft Systems***

Fumie Ono and Kenichi Takizawa (National Institute of Information and Communications Technology, Japan); Hiroyuki Tsuji and Ryu Miura (NICT, Japan)

This paper describes radio propagation characteristics in urban environment for unmanned fixed-wing aircraft (UA) system. We have conducted a measurement campaign in order to characterize ground-to-air radio channels for small unmanned aircraft system at several sites, including urban and non-urban environment. This paper shows some measurement results of ground-to-air link in urban environment. It was shown that there is the suitable flight altitude for long-range ground-to-air channel in terms of radio propagation.

08:00 - 10:20

S1.9: Antennas for base stations and handheld devices

Room: Tasman A

Chairs: Kin-Lu Wong (National Sun Yat-Sen University, Taiwan), Prayoot Akkaraekthalin (KMUTNB, Thailand)

08:00 *Beamwidth Control of Base Station Antennas Employing Reflectors and Directors*

Can Ding (University of Technology Sydney (UTS), Australia); Sun Haihan (University of Technology Sydney (UTS), P.R. China); Y. Jay Guo and Peiyuan Qin (University of Technology, Sydney, Australia); Yintang Yang (Xidian University, P.R. China)

The effects of reflectors and directors on the radiation pattern of a base station antenna are studied. A ±450 linear-polarized cross-dipole with an operating band from 1.7 GHz to 2.7 GHz is designed as an example. The antenna is then encircled by a conducting wall constructed using vertical reflectors to control its horizontal half-power beam-width (HPBW). Subsequently, cross-directors are placed above the antenna, which provides another solution to control the HPBW. A parametric study is conducted, and the findings can serve as design guidelines for the design of wide band base station antennas.

08:20 *Dual-Wideband Open-Slot Antennas with Two Open Ends for the LTE Metal-Framed Tablet Device*

Kin-Lu Wong (National Sun Yat-Sen University, Taiwan); Chih-Yu Tsai (National Sun Yat-sen University, Taiwan); Pei-Rong Wu (National Sun Yat-sen Unievrsity, Taiwan)

The open-slot antennas are very suitable for the metal-framed tablet device applications. In this article, the open-slot antenna with two open ends and simple slot structure is demonstrated to be promising candidate for achieving dual-wideband LTE operation in the tablet device, such as the smartphone and tablet computer. Two design examples are shown. The first one is a linear open-slot antenna with two open ends for the smartphone application. The second one is a U-shape open-slot antenna for the tablet computer application. Both antennas can cover the 698~960 and 1710~2690 MHz bands for the LTE operation. The operating principles and antenna performances for such open-slot antennas are presented and discussed.

08:40 *45° Polarized Slot Array Antenna with Differential Dual-End Feeding Network for Vehicle Applications*

Hao Zhou (Southeast University & State Key Lab. of Millimeter Waves, P.R. China); Hong Wei (Southeast University, P.R. China)

A 45° linearly polarized slot array antenna with differential dual-end feeding network is proposed in this paper. Radiation unit with one 45° inclined slot and two reflection cancelling vias is adopted, with its dual-end feeding potential exploited. Differential dual-end feeding network is applied to subarrays, in order to obtain a stable broadside radiation and a wide operating bandwidth. A simple filtering structure is integrated in the feeding network to reduce out-of-band monopulse radiation. A prototype array antenna with 4 × 4 radiation units at 24 GHz for vehicle applications is designed and fabricated. Experimental results on reflection coefficient, gain, and radiation patterns are consistent well with simulation predictions. The prototype array antenna can operate from 23.9 GHz to 24.9 GHz (4 %) with its reflection coefficient under -10 dB and its gain varied from 14.5 dBi to 16.5 dBi. The main beam is stable at broadside with a maximum gain of 16.4 dBi at 24.5 GHz.

09:00 *A MIMO Antenna Using Interdigital Technique for LTE and Wi-MAX on Mobile Applications*

Pongsathorn Chomtong (King Mongkut's University of Technology North Bangkok, Thailand); Prayoot Akkaraekthalin (KMUTNB, Thailand)

Demand of high data rate and channel bandwidth is concerned for modern wireless communication systems. All applications are rapidly shifting towards multiple input multiple output (MIMO). This paper focused on MIMO antenna using interdigital technique for GSM, 4G LTE and WiMAX on mobile applications. Interdigital capacitor technique can control the second harmonic as desired and reduce size of antenna from λ/2 to λ/4. However, this antenna has unidirectional radiation in both 0 and 180 degree directions. The fabricated antenna can be operated at GSM, 4G LTE (1.71-1.88 GHz) and WiMAX (3.6-3.8 GHz) frequencies with return loss (S11) below -10 dB. The simulation gain is 3.0 dB. The antenna is designed on an FR-4 substrate. The experimental results of the fabricated antenna agree very well with simulation expectations using CST package.

09:20 *Bandwidth Enhancement of HF Antennas Mounted on Military Platforms Using a Characteristic-Modes-Based Design Approach*

Ting-Yen Shih and Nader Behdad (University of Wisconsin-Madison, USA)

Narrow bandwidth is a challenging problem for designing platform-mounted electrically small antennas in the high-frequency (HF) band. In this paper, we demonstrate a process that can be used to improve the bandwidth of a platform-mounted HF antenna or antennas by taking advantage of the presence of the platform. Specifically, we examine a simplified model for the Expeditionary Fighting Vehicle (EFV) and examine how the mounted antennas can be used to excite a desired natural resonant mode of this platform for bandwidth enhancement. The proposed approach is employed to successfully enhance the bandwidth of horizontally-polarized HF loop antennas from 0.64% to 0.79% and 0.89%, by using respectively one, two, or four half loop antennas to excite the desired mode of the EFV.

09:40 *Back to Back Patch Antenna Operated Orthogonal Polarization for Repeater Use*
Kazuo Komaki and Hisao Iwasaki (Shibaura Institute of Technology, Japan)
We proposed two new back-to-back patch antennas by proximity coupled feed for orthogonal each circularly and linearly polarization. Two rectangular patches are arranged relative to the ground plane.The proposed patch antennas have bi-directional radiation patterns. Good input impedance, axial ratio, isolation and radiation pattern were obtained by simulated on HFSS. Then, the proposed patch antenna is useful of the repeater use for various mobile communication systems. In final paper, experimental results will be presented.

S2.9: Multi-band and wide-band antennas III

Room: Tasman B

Chairs: Alexandru Tatomirescu (Aalborg University, Denmark), Rashid Saleem (University of Engineering and Technology, Taxila, Pakistan)

08:00 *Comparative Analysis of Broadband Pulses for an UWB Dielectric Resonator Antenna*
Mian Iqbal and Karu Esselle (Macquarie University, Australia)
This paper investigates the time-domain characteristics of an ultrawideband (UWB) dielectric resonator antenna (DRA) for two UWB input pulses. The computed spectrum amplitude of a fifth-order Gaussian pulse has better compliance, as per FCC mask, compared to a first-order Rayleigh pulse. The correlation between the input pulses and the radiated pulses in many directions were found to be less when the antenna is excited by the first-order Rayleigh pulse. On the contrary, with the fifth-order Gaussian pulse excellent correlation factors are achieved in most directions. Therefore, this DRA with the fifth-order are suitable for an impulse radio (IR) UWB system.

08:20 *Elliptical UWB Antenna with Quad Band Notch Functionality*
Rashid Saleem and Tayyab Shabbir (University of Engineering and Technology, Taxila, Pakistan); Sabih ur Rehman (Charles Sturt University & School of Computing and Mathematics, Australia); Muhammad Farhan Shafique (COMSATS Institute of Information Technolgy, Pakistan)
In this paper, a quad-band-notch Ultra Wideband (UWB) antenna is presented. The band-notch is achieved by introducing two meander-line slots in elliptical radiation element, a defected ground plane L-shape slot and an inverted U-slot in feed line. Four notches are achieved centered at frequencies WiMAX 3.5 GHz, IEEE 802.11a/n 5.2 GHz and 5.8 GHz and downlink X-band 7.4 GHz. The substrate employed is low-loss Rogers 5880. Measured results indicate that the proposed design not only supports UWB bandwidth requirements but also rejects four narrow bands to avoid possible interference with existing communication systems. Moreover, the proposed antenna has relatively omni directional radiation patterns in passbands.

08:40 *High-efficiency Wideband and Compact Circularly Polarized Microstrip Antenna with Wide Beamwidth*
Xi Chen, Guang Fu and Long Yang (Xidian University, P.R. China)
A novel compact circularly polarized (CP) microstrip antenna is presented, which adopts a square radiation patch with a crossed slot to improve the impedance matching and reduce the antenna sizes. Moreover, the proposed radiation structure makes the antenna a good CP property not only in the normal direction but also in the horizontal direction, so a super wide axial ratio (AR) beamwidth is obtained. Low-loss substrate and no-resistor feeding network are utilized to maximum the antenna radiation efficiency. The profile of the antenna is 0.073λ. The impedance bandwidth of VSWR≤2 is 21.9%, and the AR bandwidth of AR≤3dB is 9.1%. In the overlap band, the radiation efficiency is more than 97%, and the gain is beyond 5.1dBic. Especially, the 3dB-AR beamwidth covers more than 190°. The proposed antenna could be used in the high-speed mobile platforms of communication and navigation.

09:00 *A Novel High-Gain Quasi-Yagi Antenna with a Parabolic Reflector*
Zong Hua, Gu Haichuan, Li Hongmei, Liu Beijia, Liu Guanjun and Wu Qun (Harbin Institute of Technology, P.R. China)
The simplicity and intuitive design of traditional planar printed quasi-Yagi antennas has led to its widespread popularity for its good directivity. In this paper, a novel quasi-Yagi antenna with a single director and a concave parabolic reflector, operating in S-band, is proposed. The impedance characteristic and radiation characteristic are simulated with CST-Microwave Studio, and the antenna is fabricated and measured. The measured results indicate that the antenna which can operate at 2.28-2.63 GHz can achieve an average gain of 6.5 dBi within the operating frequency range, especially a highest gain of 7.5 dBi at 2.5 GHz. The proposed antenna can be widely used in WLAN/TD-LTE/BD1 and so on.

09:20 *Tunable Decoupling of Tri-band LTE700/GSM850/900 MIMO Antenna with a Parasitic Scatterer for Handheld Devices*
Simon Stanev, Alexandru Tatomirescu and Gert Pedersen (Aalborg University, Denmark)
This paper presents a simple tri-band coupled monopole antenna working in LTE700/GSM850/900 bands for MIMO application. A parasitic scatterer with two distributed MEMS tunable capacitors is utilized to match the impedance and mitigate the effects of mutual coupling between elements. Thus, the antenna performance is enhanced significantly by minimizing the coupling current. The prototype is evaluated through the scattering parameters, the total efficiency, the envelope correlation coefficient, radiation patterns, current distributions and fully characterized through simulations. By utilizing a simple passive decoupling structure, the total efficiency is improved with 25 % and a reduction in the envelope correlation coefficient in the order of 60 to 75% is obtained over a wide aggregated bandwidth. Due to the change in radiation mechanism for both of the antennas, orthogonal radiation patterns are formed.

09:40 *A Dielectric Biconvex Lens Design for High-gain Spiral Antenna*
Kyeong-sik Min (Korea Maritime and Ocean University, Korea)
This paper describes a design for a high-gain antenna that combines a dielectric lens and a spiral radiator. The gain of the proposed spiral antenna with a biconvex lens was remarkably increased compared with that of a conventional spiral antenna with an added conical cavity wall. The narrow beam width was reasonably achieved using the optimized biconvex lens. The author confirmed that the beam width and the average gain are greatly influenced not by the lens thickness but by the focal length.

S3.9: Small antennas II

Room: Tasman C

Chairs: Faizal Jamlos (Universiti Malaysia Perlis, Malaysia), Ronghong Jin (Shanghai Jiao Tong University, P.R. China)

08:00 *AMC Substrate Inspired Small Antenna MACKEY*

Tetsuo Moroya, Masaki Kotaka, Shigeru Makino, Keisuke Noguchi, Tetsuo Hirota and Kenji Itoh (Kanazawa Institute of Technology, Japan)

Various domestic appliances which can use the WiFi are becoming more common. Therefore it is necessary to establish a design method for installing them a small antenna. This paper shows about a proposal of the model that has a dipole antenna unified with an AMC (Artificial Magnetic Conductor) substrate inspired small antenna. As a design example, VSWR and impedance characteristics are shown using typical design parameters. On parametric studies, relative bandwidth and radiation patterns are shown. Each result was analyzed by using FEM.

08:20 *Compact Dual-Band Parasitic Dipole Antenna for Harmonic Transponders*

Pascal Hirsch (University of Tasmania & CSIRO, Australia); Andrew R Weily (CSIRO, Australia); Paulo de Souza (CSIRO Computational Informatics, Australia)

A compact dual-band antenna employing parasitically coupled dipoles in an open-sleeve dipole configuration for use in harmonic transponders at 2.475 / 4.95 GHz is proposed. Its theoretical performance characteristics between 2 and 6 GHz are presented as determined through full wave simulation in CST Microwave Studio. The antenna is shown to have high radiation efficiency at both the fundamental frequency and the second harmonic while allowing independent control of the two resonances.

08:40 *A Tree Shaped Monopole Antenna for GPR Applications*

Abubakar Sharif (GC University Faisalabad, Pakistan); Hassan Tariq Chattha (University of Engineering & Technology Lahore Faisalabad Campus, Pakistan); Noman Aftab (UET Lahore, Pakistan); Rashid Saleem (University of Engineering and Technology, Taxila, Pakistan); Sabih ur Rehman (Charles Sturt University & School of Computing and Mathematics, Australia)

In this paper, a UWB monopole antenna for GPR applications is presented. The antenna offers a large bandwidth from 250 MHz to more than 6 GHz and is relatively compact in size (20 cm x 22.5 cm) than other antennas operating in same frequency range. The time domain performance of this antenna is also analyzed for use in impulse based radar systems. A prototype of antenna was manufactured and tested to validate simulation results.

09:00 *Constant Near-Field Gain for Folded Loop Antennas in Normal Saline At 6.78MHz*

Nozomu Ishii (Niigata University, Japan); Lira Hamada and Soichi Watanabe (National Institute of Information and Communications Technology, Japan)

It is required that specific absorption rate of mobile devices operated in HF band should be evaluated by using a calibrated probe. In this paper, we propose an extension of reference antenna method, which is one of methods for calibrating the probe. As a reference antenna, we examine a circular folded loop antenna immersed in normal saline solution. If its perimeter is well selected, constant near-field gain can be realized in its near-field region. And, to reduce its size, the number of folding should be larger. Also, we show the validity of estimated formula for electric field intensity radiated by the reference antenna with its near-field gain.

09:20 *Ultra-wideband Dielectric Resonator Antenna with Circular Patch Feed*

Beijia Liu (Harbin Institute of Technology & School of Electronics and Information Engineering, P.R. China); Jinghui Qiu (Harbin Institute of Technology, P.R. China); Shu Lin (Haerbin Institude of Technology, P.R. China); Nan-nan Wang, Shengchang Lan and Alexander Denisov (Harbin Institute of Technology, P.R. China)

A novel dielectric resonator antenna with an ultra-wideband (UWB) bandwidth and great time-domain performances has been proposed. The proposed feed for cone dielectric resonator antenna is a circular patch, which has the potential to achieve ultra-wideband characteristic. The operating frequency range of the antenna is 2.77-11.63GHz. The design provides constant group delay, consistent omni-directional characteristics and high efficiency. The overall dimension of the proposed antenna is 24.3mm×32.6mm2 with 6.08mm thickness. The proposed antenna provides the valuable dielectric resonator antenna design and shows great value in the fields of breast cancer detection systems.

09:40 *Occupied Bandwidth Comparison of BBOST-CPM with Two Transmit Antennas*

Kazuyuki Morioka, Naoki Kanada, Shunichi Futatsumori, Akiko Kohmura, Naruto Yonemoto and Yasuto Sumiya (Electronic Navigation Research Institute, Japan); David Asano (Shinshu University, Japan)

Continuous phase modulation (CPM) has constant envelope and good spectral properties, so it is suitable for satellite communication systems which require high power amplifiers. On the other hand, recent broadband mobile communication systems use space time block codes (STBC) to achieve channel gain by using multiple antennas. Burst based orthogonal space time-continuous phase modulation (BBOST-CPM) is a combination of orthogonal STBC and CPM which takes advantages of both merits. In this paper, we compare the occupied bandwidth of BBOST-CPM with two transmit antennas. We consider the relationship between modulation parameters and occupied bandwidth in detail. The results are useful for designing BBOST-CPM for future satellite communication systems.

10:00 *Effect of Different Substrates on Slotted Log Periodic Fractal Koch Antenna*
Nur Akmal Abd. Rahman and Faizal Jamlos (Universiti Malaysia Perlis, Malaysia)
This paper discussed about the effect of different substrates on Slotted Log Periodic Fractal Koch Antenna (LPFKA). This log periodic antenna is comprised of ten radiating elements with titled slot angles and placed on both sides of the substrate in crisscross arrangement. This antenna was designed at frequency between 0.47 GHz and 0.79 GHz which focus on UHF TVWS bands. A comprehensive study between the performances of the proposed antenna on different substrates is carried out. With the gains from 7.07 dBi to 7.95 dBi and reflection coefficient below than -10 dB over desired frequencies, this antenna is suitable and has a big potential for UHF TVWS applications.

08:00 - 10:00

S4.9: Millimeter-wave antennas and devices II

Room: Wellington

Chairs: Mike Faulkner (Victoria University, Australia), Shengchang Lan (Harbin Institute of Technology, P.R. China)

08:00 *A Frequency Invariant Beamformer for Channel Parameter Estimation in Millimeter Wave Bands*
Ines Carton, Wei Fan and Gert Pedersen (Aalborg University, Denmark)
Millimeter wave (mm-wave) bands offer vast amounts of unlicensed and unused spectrum that could potentially be utilized by future (5G) wireless systems. Accurate channel characterization at mm-wave bands is required for system design and performance analysis of future 5G communication systems. Knowledge of delay and angle of arrival (AoA) of the incoming multipath components are especially important for future applications at these frequencies. This paper discusses the use of a frequency invariant beamforming (FIB) technique with a uniform circular array (UCA) for the estimation of delay and AoA parameters at mm-wave bands. Simulations are performed for a multipath channel showing the advantages of the discussed frequency invariant techniques compared to traditional beamforming approaches.

08:20 *Multilayer Substrate-Integrated-Waveguide Aperture-Coupled Antenna Array for Millimeter-Wave Handset Device*
Seong Jin Park, Dong Hun Shin and Seong-Ook Park (Korea Advanced Institute of Science and Technology, Korea)
A substrate-integrated-waveguide (SIW) aperture-coupled antenna array is presented at millimeter-wave band. The antenna design is located on the upper part of the substrate fixed with a half size of Samsung Galaxy Note 4. The antenna array has been implemented with the multilayer structure which is realized by stacking three substrates and a copper plate. The simulated results are validated with the measured one. The proposed antenna is a good candidate for millimeter wave handset device.

08:40 *On-Chip mm-Wave Single Pixel Imager for Biomedical Applications*
Mostafa Zaky (Faculty of Engineering, Cairo University, Egypt); Islam Eshrah, Ahmed Mohieldin and Ahmed Eladawy (Cairo University, Egypt)
In this work, a mm-Wave single pixel imager is presented. The proposed design is composed of two on-chip dipole antennas over an Artificial Magnetic Conductor (AMC). The transmitting antenna has more than 2 dBi gain at the broadside direction around 90 GHz and about 18-GHz matching bandwidth. Simulations of the coupling between transmitting (Tx) and receiving (Rx) antennas show an object resolution of 2 mm x 2.3 mm and 0.2 dB per unit increase in the relative permittivity. Full-wave simulations are used to obtain the results.

09:00 *A Metamaterial Absorber for Reducing False Image in 24GHz Automotive Radar System*
Eun Jeong, Jinpil Tak and Jaehoon Choi (Hanyang University, Korea)
In this paper, a metamaterial absorber for reducing false image in automotive radar system is proposed. The unit cell of the proposed absorber consists of an electric LC (ELC) resonator and a ground plate. The ELC resonator is composed of two symmetric Spiral Split Ring Resonators (SSRRs) with slightly different absorbing band. The aim of this absorber is to improve the performance of 24 GHz automotive radar by absorbing scattered wave in the vicinity of the radar receiver. The proposed absorber exhibits the first peak at 23.1 GHz with an absorption of 93 % and exhibits the second peak at 24.1 GHz with an absorption of 96 %. Total full width at half maximum (FWHM) is 7.7% (1.85GHz) at 24 GHz.

09:20 *A Novel 24GHz Microstrip Array Module Design for Bioradars*
Shengchang Lan, Yang Xu, Hongjun Chu, Jinghui Qiu, Zonglong He and Alexander Denisov (Harbin Institute of Technology, P.R. China)
In this paper, a new millimeter-wave transmitting/receiving antenna module for bioradar sensors was proposed. This antenna was designed operating at 24 GHz for remote contactless evaluation of the human organism adaptation to physical and mental stress. This module was divided into two parts, both of which were implemented by a microstrip array antenna sub-module. The feed networks were also optimized for impedance matching to eliminate the signal self-mixing. This module had a dimension of 56×64 mm2, which made it easy to install on the roofs above the beds to monitor the heart movement activity and respiration pattern variability of burned patients or people in stress. The simulation results showed its good performance in bioradar applications.

09:40 *Effects of mm-Wave Propagation Channels on Technology Choices for 5G on-Frequency Repeaters*

Shabbir Ahmed, Robabeh Antiohos and Mike Faulkner (Victoria University, Australia)

Wireless systems at mm-wavelengths have poor in building coverage, which is encouraging the study of on-frequency relays and repeaters. Such devices suffer from loop-back interference (LI) that can increase noise and distortion and cause device instability. Cancelling loops can be used to null the strongest multipath LI components. We conduct LI measurements to ascertain the reduction of LI vs the number of cancelled paths. The required number of cancelled paths appears to increase with the square root of the channel bandwidth as more paths are resolved. DSP cancelling appears to be the the most practical solution because of the difficulty of implementing wideband delays and the absence of a significant direct path leakage between the repeater's transmit and receive antennas.

08:00 - 10:20

S5.9: Antenna arrays III

Room: Auditorium

Chairs: Ying Liu (Xidian University, P.R. China), Eko Tjipto Rahardjo (University of Indonesia, Indonesia)

08:00 *Gain Enhancement of a Dual Feed Microstrip Array Antenna Using Parasitic Elements*

Hiroshi Satow (University of Saga, Japan); Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

In this paper an in-phase/anti-phase dual feed microstrip array antenna with parasitic elements is proposed to improve the antenna's gain and it is numerically evaluated. The proposed antenna provides various kinds of functionality such as direction-of-arrival estimation, beam steering and polarization switching with a simple structure. Better than 2-dB gain enhancement is expected by using the parasitic elements. The separation of the parasitic elements is also discussed. The separation of 0.8λ0 provides the highest gain for both the in-phase and anti-phase feeds.

08:20 *The Design Method of Low-cross-polarization Reflectarray Antenna*

Yuka Fujii, Shigeru Makino, Tetsuo Hirota, Keisuke Noguchi and Kenji Itoh (Kanazawa Institute of Technology, Japan)

A reflectarray antenna is composed of a flat reflector and a feed horn and is sometimes compared with a offset parabola antenna. Generally, the efficiency and the gain are lower than those of the parabola antenna. And also the bandwidth is narrower than that of the parabola antenna. On the other hand, the advantage of reflectarray antenna is that the cross polarization component is lower than that of the parabola antenna because of its geometrical configuration. However the cross polarization component will occur because of its own reasons. In this paper, the mechanism of cross polarization of the reflectarray antenna will be clarified and design method of reflectarray antenna with low-cross-polarization will be shown. The validity of the design method will be shown by simulations and measurements.

08:40 *A Hybrid Technique Linear Sparse Array Antenna Design Approach*

Efri Sandi, Fitri Yuli Zulkifli and Basari Basari (Universitas Indonesia, Indonesia); Eko Tjipto Rahardjo (University of Indonesia, Indonesia)

In this paper we proposed a new approach linear sparse array antenna design with a hybrid technique of non-uniform elements spacing and combinatorial cyclic different sets (CDS) to achieve high resolution requirement in Radar applications. As an example, the spatial dimension of 64 linear microstrip full array configuration (d = 0.7λ) is reduced to 32 elements linear sparse array configuration with non-uniform elements spacing using CDS integer. The simulation result showed the sparse array beamwidth resolution was improve compared to full array configuration with small sidelobe level degradation.

09:00 *A Simple Reconfigurable BiCMOS Active Inductor and Its Implementation in A Phase-Shifter Unit Cell*

Sudipta Chakraborty, Budhaditya Majumdar, Michael Heimlich and Karu Esselle (Macquarie University, Australia)

An active inductor based phase-shifter unit cell is proposed. The active inductor is designed with BiCMOS process technology and is implemented with only one heterojunction bipolar transistor and one field-effect transistor without any requirement of complicated transconductance amplifier design. A phase-shifter unit cell is implemented with a high-pass T-Section with two varactors in series and the active inductor as a shunt. Relative phase variation is achieved by tuning the active inductor or by varying the effective junction capacitance of the varactors. Maximum relative phase variations of 23.7 degrees and 38.6 degrees are achieved at 4 GHz by exclusively tuning the gate voltage and varactor capacitance, respectively. The relative phase variations at 18 GHz are 6.0 degrees and 8.0 degrees, respectively, for the same exclusive conditions.

09:20 *Design of a Two-Dimensional Quasi-Yagi Array Antenna with Low Sidelobe*

Jingtao Zhu, Guanghua Lu, Jian Guan and Chunsheng Luo (University of Science and Technology of China, P.R. China)

The paper presents the design of an end-fire array antenna with low sidelobe. The presented antenna operates on X-band consisting of 8×8 microstrip Quasi-Yagi antenna elements. In order to obtain -21dB sidelobe level and specific half power beamwidth, particle swarm optimization (PSO) is applied to optimize the power distributions of the feeding network and the element spacing. According to the optimized power distributions, two corresponding non-isolated microstrip power dividers are designed to feed the two-dimensional array. Finally, the array is fabricated and the measure results show a maximum sidelobe level of -18dB is achieved on the band from 8.9 to 9.6GHz with a minimum gain of 18.6dB.

09:40 ***Radiation Characteristics of an Aperiodic Array Antenna Using One Type of Diamond Tile***

Takahiro Yamamoto, Shigeru Makino, Tetsuo Hirota, Keisuke Noguchi and Kenji Itoh (Kanazawa Institute of Technology, Japan)

A method to reduce the cost of a phased array antenna involves the use of subarrays composed of several element antennas and the installation of a phase shifter to each subarray, rather than to each element antenna. In this method, it is important to suppress grating lobes because the periods of the subarrays are usually large compared with the wavelength. This paper proposes an aperiodic array antenna using one type of diamond tile as subarrays, which has both low cost and low sidelobe characteristics.

10:00 ***Blind Signal Separation Using SOBI Algorithm Under the Effect of Mutual Coupling of Array***

Keita Matsubara, Nobuyoshi Kikuma and Kunio Sakakibara (Nagoya Institute of Technology, Japan)

The role of radio wave monitoring systems is important to maintain regular radio environments in which we can use the radio waves effectively.Blind signal separation techniques using array antennas are expected to bring many advantages in the radio monitoring system. In several techniques, Independent Component Analysis (ICA) attracts much attention because of its convenience and effectiveness. In this paper, we focus on SOBI algorithm in ICA and examine the performance under the effect of mutual coupling of array elements.

10:40 - 11:15

S1.10.1 - Invited: Broadband 3D metamaterial carpet cloak

Prof Hongsheng Chen - Distinguished Professor The Electromagnetics Academy at Zhejiang University College of Information Science & Electronic Engineering State Key Laboratory for Modern Optical Instrumentation

Room: Tasman A

Chair: Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia)

We propose and demonstrate ultra-broadband three dimensional carpet cloaking for full polarization. Based on rigorous nonlinear transformation optics, we obtain a group of inhomogeneous constitute parameters. A non-resonant metamaterial, which exhibits broadband magnetic and electric anisotropy with little dispersion, is used as a main building block in the cloak design. Nearly perfect cloaking performance is confirmed over a broad bandwidth with frequency scanning measurement. In particular, the experimental result shows that phase is well preserved by the cloak.

S4.10.1 - Invited: Enhancing the sports experience: Electromagnetics for Fun, Profit & Audience Engagement

Prof David Thiel- Deputy Head of School (Research), Griffith School of Engineering, Griffith University

Room: Wellington

Chair: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

A majority of Australians, regardless of age, ethnic background or wealth, get seriously interested in elite sport during major international events (the Olympic Games, World Championships, Test series, Grand Slams, etc) through to developmental child activities in very early years. Sophisticated wireless systems and other electronics are now in the affordable mass consumer market through smart phone apps or fashionable sports bands. Griffith University's SABEL Laboratories in the Engineering School continue to develop electronic systems for sports performance monitoring based on low cost, wearable technologies. Player activity, player position, player physiology and player fatigue are of great interest to the viewing public and the coaching staff as well as the athletes themselves. There is much to be gained from this new technology. This talk presents an overview of radio communications and sensing systems used in training and competition and the benefits of technologies to a sports obsessed public.

S5.10.1 - Invited: Reconfigurable Magneto-electric Dipole Antennas

Prof Kwai Man Luk - City University of Hong Kong, Hong Kong, P. R. China

Room: Auditorium

Chair: Karu Esselle (Macquarie University, Australia)

With the rapid development of wireless communications in the past decades, various new antenna techniques are investigated to meet the requirements of fast developing wireless communication systems. By adapting the operating frequency or the radiation characteristics, reconfigurable antennas can cope with the changing system requirements or environmental conditions. Therefore, reconfigurable antennas can significantly improve the efficiency of spectrum usage and also provide additional levels of functionality for the systems.Various antenna structures have been utilized for the design of reconfigurable antennas, such as patch antennas, slot antennas, monopole and dipole antennas, etc. However, only a few of these designs can achieve good unidirectional radiation fulfilling the requirements of antennas for some fixed infrastructures, such as base stations. Recently, a new class of wideband antennas designated as the magneto-electric dipoles was proposed. These antennas were designed based on the complementary antenna concept. The basic structure consists of a planar electric dipole and a shorted quarter-wave patch antenna. These novel antenna elements have many attractive features, including wide impedance bandwidth, low cross polarization, low back radiation, nearly identical radiations in the two principal planes, stable radiation pattern, and constant antenna gain over the operating frequency range. Considering their excellent performances, the magneto-electric dipole antennas are very competitive candidates for reconfigurable unidirectional antennas. In this talk, the latest development of the reconfigurable magneto-electric dipole antennas will be presented, including frequency reconfigurable and beamwidth reconfigurable designs.

11:15 - 11:50

S1.10.2 - Invited: Metamaterial-Based Electromagnetic Space, Time and Spacetime Dispersion Engineering

Prof Christophe Caloz - École Polytechnique de Montréal, Canada
Room: Tasman A
Chair: Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia)

Everything in our universe occurs in space, time, and spacetime where space and time are interdependent. These concepts are therefore fundamental across all areas of human activities, including history, economy, philosophy, arts and sciences. The author believes systematic endeavours in manipulating waves in space, time and spacetime will bring about considerable opportunities towards the development of tomorrow's electromagnetic science and technology. Manipulation waves in space essentially consists in engineering their spatial frequency (k) spectrum, which may be performed using conventional electromagnetic structures, such as apertures, antennas, lenses, polarizers, photonic crystals, Talbot imagers, optical masks, etc. However, the frontiers of spatial dispersion engineering may be pushed far beyond the current state of the art, particularly using the novel concept of metasurfaces. The talk will present several innovations in this area, including magnetless nonreciprocal gyrotropy, generalized refraction, multiple wave transformation, multi-refringence, and orbital angular momentum multiplexing. In time, manipulating waves essentially consists in engineering their temporal frequency (ω) spectrum, as partly done in ultrafast optics where oscillations are too fast to be handled by digital signal processors, and where real-time chirping and nonlinear materials and devices have therefore to be used instead. Such concepts have been little explored in electromagnetics, and may represent a solution to the exploding demand for faster and more reliable radio if sufficient progress is made. The author developed in his group metamaterial-inspired structures called phasers, which provide specifiable group delay versus frequency responses to perform unprecedented temporal dispersion engineering. The talk will present the related Radio Analog Signal Processing (R-ASP) concept and technology, and demonstrate a number of related applications, such as spectrum sniffing, real-time Fourier analysis, and dispersion code multiple access. Aforementioned concepts typically concern monochromatic spatial dispersion engineering and mono-directional temporal dispersion engineering. Combining the two aspects in simultaneous space and time dispersion engineering, as nature does it in rainbows and humans in holograms, will open up further horizons in electromagnetics processing. The talk will also address this area, first introducing the fundamental concept of temporal to spatial frequency mapping, and next describing a few recent applications, including real-time spectrogram analysis and two-dimensional mapping for the processing of ultrafast waves. Finally, novel concepts in electromagnetic spacetime discontinuities, where space and time are interdependent as in the theories of special and general relativity, will be introduced and discussed as a potential platform for future developments in electrodynamics.

S4.10.2 - Invited: Advanced Phased Arrays and Reflector Antennas for 21st Century Satellite Communication Payloads

Dr Sudhakar Rao - Technical Fellow, Northrop Grumman, USA
Room: Wellington
Chair: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

21st century has so far seen several new satellite services such as local-channel broadcast for direct broadcast satellite service (DBS), high capacity K/Ka-band personal communication satellite (PCS) service, hosted payloads, mobile satellite services using very large deployable reflectors, high power hybrid satellites etc. All these satellite services are driven by the operators need to reduce the cost of satellite and pack more capability into the satellite. Antenna sub-system design, mechanical packaging on the spacecraft, and RF performance become very critical for these satellites. This talk will cover recent developments in the areas of antenna systems for FSS, BSS, PCS, & MSS satellite communications. System requirements that drive the antenna designs will be presented initially with brief introduction to satellite communications. Phased array antenna and reflector antenna designs will be covered in this talk.Advanced antenna system designs for contoured beams, multiple beams, and reconfigurable beams will be presented. Contoured beam antennas using dual-gridded reflectors, shaped single reflectors, and shaped Gregorian reflectors will discussed. The figure of merit of these antennas using gain-area-product (GAP) will be addressed. Multiple beam antenna (MBA) concepts and their advantages compared to conventional contoured beams will be introduced. Various designs of the MBA for DBS, PCS, and MSS services will be discussed along with practical examples. Recent advances in feed technology and reflector technology will be addressed and few examples. Advances in multi-band antennas covering multiple bands will be presented. Topics such as antenna designs for high capacity satellites, large deployable mesh reflector designs, low PIM designs, and power handling issues will be included. Introduction to remote sensing antennas with examples will be included in the talk. Advanced high power test methods for the satellite payloads will be addressed. Brief introductions to TT&C antennas, passive inter modulation products (PIM) and multipaction for satellite payloads will be given. Antenna test ranges and software tools required for test and design of 21st century satellite antennas will be presented. Future trends in the satellite antennas will be discussed. At the end of this talk, engineers will be exposed to typical requirements, designs, hardware, software, and test methods for various satellite antennas.

S5.10.2 - Invited: Metamaterial-Inspired Electrically Small Antennas Integrated Into Structural Materials

Prof. Richard W. Ziolkowski - University of Technology Sydney & University of Arizona
Room: Auditorium
Chair: Karu Esselle (Macquarie University, Australia)

An electrically small Egyptian axe dipole antenna has been designed and integrated into a glass fiber reinforced polymer (GFRP), a structural material now commonly found in most mobile platforms. The integration is accomplished by sewing the antenna with conductive threads into the GFRP prepreg and accounting for dimensional variations after curing under high temperature and pressure in an autoclave. The simulated and measured reflection coefficient values and radiated field patterns are in good agreement. These comparisons demonstrate that the antenna is nearly completely matched to the source without any matching circuit and radiates as an electric dipole.

11:50 - 12:25

S1.10.3 - Invited: MetaLine, MetaSpiral, and MetaHelical Antennas

Prof. Nakano - Hosei University, Tokyo Japan
Room: Tasman A
Chair: Ananda Sanagavarapu Mohan (University of Technology Sydney (UTS), Australia)

Normally, electromagnetic properties in nature are right-handed. Antennas having this property are designated as natural antennas. On the other hand, antennas having electromagnetic properties that are not found in naturally occurring materials are designated as metamaterial-based antennas (simply referred to as metamaterial antennas). This talk is composed of three chapters and discusses metamaterial-based antennas. Chapter 1 reveals that a metamaterial-based straight line antenna (MetaLine antenna) forms a linearly polarized (LP) beam that scans from the backward direction, through the broadside direction, to the forward direction (BBF scanning) with change in operating frequency. It is also revealed that the MetaLine can realize a circularly polarized (CP) BBF scanning beam. These BBF scanning behaviors cannot be achieved with a corresponding natural straight line antenna having a right-handed property.The metamaterial-based spiral (MetaSpiral) antenna presented in Chapter 2 and the metamaterial-based helical (MetaHelical) antenna presented in Chapter 3 are shown to create a left-handed CP beam across a specific frequency band and a right-handed CP beam across a different frequency band. In other words, each of the MetaSpiral and MetaHelical radiates a counter dual-band CP beam. It should be emphasized that the antenna height for the MetaSpiral is approximately 1/100 of the wavelength at the lowest operating frequency, in contrast to the 1/4 wavelength antenna height of conventional antennas backed by a conducting plate (reflector).

S4.10.3 - Invited: Developing 5G for Mission Critical Machine Communications

Dr. David Soldani - Huawei
Room: Wellington
Chair: Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia)

The talk describes a multitenant network and services vision and the most important 5G wireless, wireline and media enabling technologies, leveraging Software Defined Networking (SDN), Network Functions Virtualization (NFV), High Performance (HPC) and Mobile Edge Computing (MEC). Special focus will be plance on Mission Critical Machine Communications (MCC) and the main research challenges to achieve higher speed and lower latency with a high degree of reliability. Conclusions will be drawn on the main standardization activities and roadmap towards the IMT for 2020 and beyond.

S5.10.3 - Invited: Meta-Atom Materials for RF Microwave Substrates Using Additive Manufacturing (3D Printing)

Prof Yiannis Vardaxoglou - Loughborough University, UK
Room: Auditorium
Chair: Karu Esselle (Macquarie University, Australia)

Metamaterials which are essentially periodic structures with metallic/dielectric and/or magnetic inclusions in a host material, produce truly novel electromagnetic (EM) properties, such as artificial dielectrics and magnetics, lenses etc. These can be in planar form to represent a bespoke RF/microwave substrate, as well as spherical formations for dielectric lenses (e.g. Luneburg) and imaging horn antennas. Placing these novel structures into the complex electronic design world such as multilayer circuits or radiated antennas will open up a new way of designing and manufacturing electronics, aiming towards a single process function from CAD to manufacture. The focus of this paper is on the generic synthesis of metamaterials, by placing these so called meta-atom inclusions in an ordered and systematic manner, analogous to compiling the 'periodic table' of metamaterials. The inclusions are of the order of microscale dimensions clustered together to form unique patterns. This opens up a plethora of new structures to be formed which do not currently exist. These will not only will aid in improving existing applications but it will break existing boundaries for new applications to be formed. Depending on the ability to make these in small, medium and large scale, the frequencies span from RF/Microware to THz. The impetus of this research is to make a step change in current application of metamaterials and a discernible improvement to the communications link through increasing the capacity for more data improving functionality and productivity. We will present engineered structures with various manufacturing technologies using conventional photolithography and additive manufacturing (3D printing).

13:00 - 15:20

S1.11: Antenna measurements II

Room: Tasman A

Chairs: Ronghong Jin (Shanghai Jiao Tong University, P.R. China), Aaron Chippendale (CSIRO, Australia)

13:00 *Measurement Jig Using Semi-Rigid Cable for Differential Impedance Measurement by S-Parameters*

Ryuta Tozawa, Takayuki Sasamori, Kazuma Endo, Teruo Tobana and Yoji Isota (Akita Prefectural University, Japan)

Recently, the S-parameter method using a vector network analyzer and a measurement jig instead of a balun was proposed whereby the differential input impedance of a balanced-fed antenna were obtained. As no balun is used, measuring impedance over a wide frequency bandwidth is now possible. To improve measurement accuracy of the S-parameter method, the dependence on thickness of the semi-rigid cable used for the measurement jig is obtained from the results of calculations using the FDTD method. Two types of jigs each made from semi-rigid cables of differing thickness were fabricated, and the input impedance of the dipole antenna calculated using the S-parameter method. The impedances were compared with those obtained from the available theories by King and calculation results of delta-gap-fed dipole antennas. Results from the S-parameter method agree with the available theories by King and the calculated results of the conventional model of a dipole antenna, over a range of about 6 GHz or less.

13:20 *Study on Multiple Antenna Combining for Sequentially Switched Antenna Array Receivers*

Takahiro Fujita and Shinichiro Yamamoto (University of Hyogo, Japan); Satoru Aikawa (Hyogo University, Japan); Satoshi Tsukamoto (ATR, Japan); Julian Webber (Advanced Telecommunications Research Institute International, Japan); Tomoaki Kumagai (ATR, Japan)

The traffic from many smartphones in a bullet train is increasing and there is a fear of the capacity lack in the train-unit entrance circuit. In the Sequentially Switched Antenna Array Receiver, the array antenna elements fix the receiving point against the travel of the bullet train. In addition, it is necessary to synchronize the switching with the sampling period. We propose a multiple antenna combining scheme that satisfies the requirements for the sequentially switching, and show its effectiveness by computer simulations using measurements that is based on experimental data.

13:40 *Measured Aperture-Array Noise Temperature of the Mark II Phased Array Feed for ASKAP*

Aaron Chippendale, Andrew Brown, Ron Beresford, Grant Hampson, Robert Shaw, Douglas B Hayman, Adam Macleod, Ross Forsyth, Stuart G Hay, Mark Leach, Chris Cantrall, Michael Brothers and Aidan Hotan (CSIRO, Australia)

We have measured the aperture-array noise temperature of the first Mk. II phased array feed that CSIRO has built for the Australian Square Kilometre Array Pathfinder telescope. As an aperture array, the Mk. II phased array feed achieves a beam equivalent noise temperature less than 40 K from 0.78 GHz to 1.7 GHz and less than 50 K from 0.7 GHz to 1.8 GHz for a boresight beam directed at the zenith. We believe these are the lowest reported noise temperatures over these frequency ranges for ambient-temperature phased arrays. The measured noise temperature includes receiver electronics noise, ohmic losses in the array, and stray radiation from sidelobes illuminating the sky and ground away from the desired field of view. This phased array feed was designed for the Australian Square Kilometre Array Pathfinder to demonstrate fast astronomical surveys with a wide field of view for the Square Kilometre Array.

14:00 *A Corrugated Horn Antenna with A Dielectric Lens for High Gain Performance*

Hojoo Lee, Juneseok Lee and Jaehoon Choi (Hanyang University, Korea)

A corrugated horn antenna with a dielectric lens for high gain performance is proposed in this paper. The proposed antenna consists of a corrugated conical horn antenna and a dielectric lens at the aperture. The material used for the dielectric lens is Teflon having the relative permittivity of 2.1. The proposed antenna provides wide bandwidth to cover the X band(8~12GHz) and high gain performance. The simulated 10-dB return loss bandwidth is 7.2GHz ranging from 6.5GHz to 13.7GHz with the antenna gain of 23.6dBi at the center frequency(10GHz). The overall dimension of the proposed antenna is 110 mm × 110 mm × 135 mm. The high gain performance of the proposed antenna is typically suited for level transmitter system of a tank containing gas having low-permittivity.

14:20 *A Study on the Effective Pattern of Magnetic Sheet Considering Their Characteristics Attached on NFC Antenna*

Takaho Sekiguchi and Yoshinobu Okano (Tokyo City University, Japan); Naoki Ohmura and Satoshi Ogino (Microwaveabsorbers inc., Japan)

In case of payment system with NFC (Near Field Communication)/HF-RFID (Radio Frequency IDentification) installed into the smart-phone, NFC antenna's communication performance at 13.56MHz is deteriorated by the battery case or circuit boards. To solve this problem, the magnetic sheet with high permeability is inserted into the NFC/HF-RFID antenna and metal object. Thin magnetic compound or sintered ferrite has been used as the high permeability sheet. However, these sheet thicknesses could not be suppressed to improve the NFC/HF-RFID antenna's performance. In order to make thickness of these materials thinner, we propose amorphous magnetic sheet. Besides because the loss of amorphous magnetic sheet is large, that loss suppression technique is also proposed.

14:40 ***An Analytical Approach for Antenna Performance Evaluation for MIMO Systems***
Chaowei Wang (Beijing University of Posts and Telecommunications & Schoole of Electronics Engineering, P.R. China); Songsong Xiao (Beijing University of Posts and Telecommunications, P.R. China); Weidong Wang (Beijing Unversity of Posts and Telecommunications, P.R. China); Cheng Wang (Beijing University of Posts and Telecommunications, P.R. China); Shuaijun Liu (Beijing University of Posts and Telecommunications & Information and Technology Lab, School of Electronic Engieering, P.R. China)
An analytical approach for antenna performance evaluation in multiple-input-multiple-output (MIMO) systems is proposed. By considering the elevation angles of the electromagnetic rays at both the base station (BS) and mobile station (MS), a three-dimensional (3D) channel model is introduced. Then the analytical approach which evaluates the effects of antenna configurations on channel capacity and diversity performance of MIMO systems is derived. In order to verify the proposed method, a link-level simulation is implemented, in which the effects of isolation on system throughput, and the effects of envelope correlation coefficients (ECC) on equivalent diversity gain are evaluated, respectively. The simulation results validated our proposed approach.

15:00 ***Tidal Level Estimation Using a 5GHz Band Wireless Access System***
Hiroaki Taka (Future University Hakodate, Japan); Masaaki Wada (Future University-Hakodate, Japan)
Recently, ICT is introducing to various fields of fishery and oceans. For example, wireless access systems are used for realizing a broadband environment at coastal areas and isolated islands. The authors also realized a marine broadband environment for small fishing vessels to manage aquatic resources. In order to establish stable use of wireless access systems, it is necessary to evaluate characteristics of wireless access systems in severe conditions such as anomalous tide level caused by a typhoon or a tsunami. In this study, the authors evaluated long- term characteristics of a wireless access system by constructing a 5 GHz band wireless access system which have propagation paths including sea surface. As a result, we could obtain RSSI data when a typhoon approached, and we confirmed that the system could maintain the communication quality. The authors also considered the possibility of the detection of anomalous tidal level from RSSI of the wireless access system.

S2.11: Computational electromagnetics II

Room: Tasman B

Chairs: Kenichiro Yashiro (Chiba University, Japan), Xiaolin Zhang (East China Research Institute of Electronic Engineering, P.R. China)

13:00 ***Multi-objective Particle Swarm Optimization for the Realization of a Low Profile Bandpass Frequency Selective Surface***
Ali Lalbakhsh, Muhammad Usman Afzal, Karu Esselle and Basit Ali Zeb (Macquarie University, Australia)
This paper presents a novel evolutionary optimization algorithm to design an extremely low profile bandpass frequency selective surface (FSS). A particle swarm optimization algorithm is interfaced with a commercial time-domain solver to design and optimize a second-order bandpass FSS at 10 GHz with 20% fractional bandwidth. Four variables are defined in the algorithm to be optimized for realization of a grid of capacitive patches and inductive strips, which constitute the bandpass FSS. Optimization led to an FSS with a total thickness of λ_0/65.

13:20 ***Accuracy Improvement of Ray Tracing Method for Between 0.8 and 37 GHz in Street Cell Environment***
Nobutaka Omaki (NTT DOCOMO INC., Japan); Tetsuro Imai, Koshiro Kitao and Yukihiko Okumura (NTT DOCOMO, INC., Japan)
Recently, mobile networks employing high-speed/high-capacity communications have been investigated extensively to satisfy the demand for the faster/larger data communication. As one of the approaches, frequency band between 6 and 100 GHz bands are the candidates to utilize the relatively wide frequency bandwidths. Accordingly, the characteristics of radio propagation loss in these frequency bands must be characterized. We investigate the characteristics of radio propagation loss in a street cell environment in the frequency bands using Ray Tracing by comparing with measurement results. RT calculation tends to exhibit estimation error as frequency increases. In this report, we propose to use alternative model with detailed building shape in intersection accounting for surface roughness. RT calculation with the proposed model is numerically evaluated to reveal the characteristics of path loss prediction. Finally, the proposed method is implemented to be compared with measurement results. Parameters of the proposed model are optimized and sufficient accuracy can be achieved in the frequencies between 0.8 and 37 GHz.

13:40 ***A Novel Marching-on-in-Time Algorithm for Analyzing Arbitrary-Structure Thin-Wire Antennas***
Xiaolin Zhang (East China Research Institute of Electronic Engineering, P.R. China); Huotao Gao (Wuhan University, P.R. China)
This paper presents a novel marching-on-in-time algorithm for analyzing thin-wire antennas with arbitrary structures. Transient charges and currents along the thin wire are iterated explicitly in a leap-frog fashion, similarly as in the finite difference time domain method. The input impedances of different types of thin-wire antennas in frequency domain are calculated through discrete Fourier Transform (DFT) and compared with those from Method of Moments (MoM), which shows that the proposed algorithm is effective and efficient, even in the case of complex wire structures.

14:00 *Efficient RCS Measurement Technique by Near-Field Far-Field Transformation Which Utilize 2-D Plane-Wave Expansion*

Shuntaro Omi (Tokyo University of Agriculture and Technology, Japan); Toru Uno (Tokyo University of Agricultural Technology, Japan); Takuji Arima (Tokyo University of Agriculture and Technology, Japan); Takao Fujii (Fujitsu System Integration Laboratories Ltd., Japan)

A near-field far-field (NF-FF) transformation technique for RCS measurement is proposed. This technique employing two dimensional plane-wave expansion enables us to measure RCS from two dimensional near-field measurement. It cause significant reduction of near-field measurement cost for relatively thin measurement targets. In comparison with other 2-D transformation techniques, this technique promised more accurate transformation by its capability of transmitting and receiving antennas correction or fast multipole method (FMM)-like source decomposition.

14:20 *Scattering From a Finite Array of Axially Magnetized Ferrite Cylinders*

Kenichiro Yashiro (Chiba University, Japan)

The scattering of E-polarlized plane wave from a finite array of axially magnetized ferrite cylinders is analysed based on the method of moments with global basis functions and Galerkin approach. To do so, the scattered wave is expressed in terms of the equivalent surface current. Furthermore, the surface impedance is introduced so that the boudary condition is imposed at the surfaces of cylinders in the unified manner as dielectric or conducting cylinders. Some numerical examples are given.

14:40 *Calculation of Permeability Tensor of Ferrites Using HE111 Mode*

Tae-Wan Kim and Byeong-Yong Park (KAIST, Korea); Seong-Ook Park (Korea Advanced Institute of Science and Technology, Korea)

A calculation of permeability tensor of ferrite is presented in this paper. The ferrite resonator that is located between two parallel metal plates is introduced. Through theoretical derivation of the proposed scheme, the splitting phenomenon of the HE111 mode can be verified. It is also found that the splitting behavior depends on the single magnetization value of the ferrite. The analysis process and calculated results are presented in detail.

S3.11: Microwave and RF devices I

Room: Tasman C

Chairs: Yifan Wang (University of Queensland, Australia), Norhudah Seman (Universiti Teknologi Malaysia, Malaysia)

13:00 *Design of Waveguide Short-Slot 2-Plane Couplers*

Dong-Hun Kim, Jiro Hirokawa and Makoto Ando (Tokyo Institute of Technology, Japan)

Waveguide short-slot hybrid and cross 2-plane couplers are proposed. Those are designed to couple in the H- and E-plane couplers, but should be considered propagation constants and coupling coefficients of plural modes in the coupled region. Satisfying these conditions, the design of the coupled region and the ports is conducted. Its achieved bandwidth is approximately 2 % restricted by the frequency characteristic of the propagating modes in the coupled region.

13:20 *Design of Wideband Microstrip-Slot Six-Port Complex Ratio Measuring Unit*

Muhamad Azrul Abdullah and Norhudah Seman (Universiti Teknologi Malaysia, Malaysia)

A wideband six-port Complex Ratio Measuring Unit (CRMU) design is presented in this paper. CST Microwave Studio is used to design the CRMU by integrating one in-phase Wilkinson power divider with stubs and three 90° microstrip-slot two-section branch-line couplers (BLCs). Wilkinson power divider is improved by implementing additional stubs at transmission line of Port 1, Port 2 and Port 3. Meanwhile, slot is placed underneath each parallel branch arm of BLC to broaden its bandwidth performance. The presented simulated result of the proposed CRMU offers good wideband performance of amplitudes and phase characteristics between 2.5 and 5.2 GHz.

13:40 *Transmission Bandwidth Enhancement Using Lateral Displacement in a Thin Flexible Single Layer Double Sided FSS*

Aliya A. Dewani, Steven O'Keefe and David V Thiel (Griffith University, Australia)

A novel low profile frequency selective surfaces (FSS) with wide stop band characteristics suitable for UWB applications consists of square loops screen printed on both sides of a thin flexible polycarbonate substrate with a lateral offset in both directions. The design provides a -10dB insertion bandwidth of 4.55 - 12.77GHz. The design delivers stop band for angular incidence in both single sided and double sided configurations up to 60o degrees. The symmetrical nature ensures identical response for TE and TM modes of polarization within 30o incidence. A comprehensive iterative analysis was made to enhance the ultra-wide bandwidth

14:00 *Studies on Filtering Characteristics of X-shaped Photonic Crystal Waveguide in Two-Dimensional Triangular Lattice by Microwave Model*

Yuting Bao (Fukuoka Institute of Technology, Japan)

For the application in wavelength division multiplexing (WDM) system, propagation and filtering characteristics of X-shaped photonic crystal waveguide composed of metallic pillars in two-dimensional triangular lattice were studied in this paper. First, symmetrical X-shaped waveguide and two types of asymmetric X-shaped waveguides were measured to compare their transmission characteristics. Next, three sets of dielectric pillars with different lengths were situated in each output waveguide as cavities. Filtering characteristics were compared to select the most applicable structure as a basic filter component in WDM system.

14:20 *An Efficient Design Method of Microstrip Filtering Antenna Suitable for Circuit Synthesis Theory of Microwave Bandpass Filters*

Masataka Ohira and Zhewang Ma (Saitama University, Japan)

This paper proposes an efficient design method of filtering antennas, enabling to apply a well-established filter design theory to the antenna design. In the design of filtering antenna, an external Q factor at input port, coupling coefficients, and a radiation Q factor of antenna need to be evaluated. However, conventional design methods have a time-consuming procedure, since a time domain response from the overall structure is required for the evaluation of coupling coefficient between resonator and antenna. For an efficient design, we propose a parameter extraction technique using only amplitude property of input reflection responses for the evaluation of both the coupling coefficient and the radiation Q factor. As an example, a third-order filtering antenna is synthesized, designed, and tested, which numerically and experimentally validates the effectiveness of the proposed design method.

14:40 *Decoupling Method for Two-element MIMO Antenna Using Meander Branch Shape*

Keisuke Okuda (Chiba University, Japan); Hiroshi Sato (Panasonic System Networks, Japan); Masaharu Takahashi (Chiba University, Japan)

Recently, MIMO (Multiple-Input Multiple-Output) technology is introduced in various small wireless applications. If MIMO antennas are mounted on such terminals, a strong mutual coupling is occurred because a distance between antenna elements is close. To solve this problem, a decoupling method for 2x2 MIMO connecting between two antenna elements by inductors has been developed. However in this method, the inductors caused loss and this is the factor of deterioration in radiation efficiency. In this paper, a new decoupling method without connecting between two antenna elements is proposed.

S4.11: Radio wave propagation II

Room: Wellington

Chairs: Thomas Fickenscher (Helmut Schmidt University, Germany), Mariyam Jamilah Homam (Universiti Tun Hussein Onn Malaysia, Malaysia)

13:00 *Dual Frequency Use Technique for 40-GHz Satellite Communication During Rainfall Attenuation*

Wataru Chujo (Meijo University, Japan); Takeshi Manabe (Graduate School of Engineeringl, Osaka Prefecture University, Japan); Kenji Suzuki (National Institute of Information and Communications Technology, Japan)

Dual frequency use technique that uses both 12- or 20-GHz and 40-GHz satellite downlinks is proposed to share resources mutually for achievement of higher communication capacity with restricted use of the satellite transmission power during rainfall attenuation. Communication capacity of the satellite downlink is estimated from the satellite availability by applying frequency diversity and dual frequency use techniques. Dual frequency use technique achieves superior communication capacity for 40-GHz attenuation range from 5 to 10 dB during rainfall when the satellite power is shared between 12- or 20-GHz and 40-GHz downlinks.

13:20 *Impact of Wind Turbine Rotor Forward Scattering on 16-QAM Based Communication System*

Muhammad Bilal Raza and Thomas Fickenscher (Helmut Schmidt University, Germany)

Rotor angle dependent amplitude and phase distortion of a radio signal is calculated using 2D Fresnel-Kirchhoff diffraction approach and verified by numerical field simulation using Uniform Theory of Diffraction (UTD). The corresponding instantaneous Modulation Error Ratio (MER) and raw data Bit Error Rate (BER) are investigated considering a 16-QAM system. Time-variant channel impulse response cannot be derived from the frequency domain model of the Fresnel-Kirchhoff formula due to inherent limitations of its approximation.

13:40 *Identification of Line of Sight by Cross Polarization Characteristic*

Atsuki Morita, Hisato Iwai and Hideichi Sasaoka (Doshisha University, Japan)

In this paper, we identified line of sight (LOS) by cross polarization discrimination (XPD). We analyzed the propagation characteristic by the Finite Difference Time Domain (FDTD) method, and statistically evaluated the performance of the LOS identification based on XPD. As a result of the evaluation, we found it is difficult to obtain sufficient identification performance only by XPD. Therefore, we developed a new identification method combining XPD and the received power. By using the method, we showed successful identification rate of about 80% could be obtained.

14:00 *DOD-based Localization Technique Using RSSI of Indoor Beacons*

Naoki Honma, Kazuki Ishii and Yoshitaka Tsunekawa (Iwate University, Japan); Hiroto Minamizawa and Atsushi Miura (Embedded Resource Integration, Japan)

This paper presents direction of departure (DOD)-based localization technique suitable for indoor environment. Localization is performed by estimating direction from known multiple beacons, where each of them comprises two antennas and 180-deg hybrid. DOD estimation is performed only from received signal strength indicator (RSSI), which does not have phase information. Indoor measurement campaign has been carried out and shown that the terminal node can successfully identify its location with 0.7 m accuracy.

14:20 *Comparison of Phase Scintillations During Low and High Solar Activity Periods*
Nur Mahfuzah Abdul Rashid and Mariyam Jamilah Homam (Universiti Tun Hussein Onn Malaysia, Malaysia)
This study compares and analyzes phase scintillation σϕ during periods of low and high solar activity. This study focused on the low solar activity from July 2007 to June 2008 and the high solar activity from July 2013 to June 2014. The data were obtained from a GISTM receiver at the Wireless and Radio Science Centre, Universiti Tun Hussein Onn Malaysia (1°52'N, 103°06'E). Results show that the monthly mean σϕ value is within the range of 0.051 and 0.064 rad during high solar activity. The value during low solar activity ranges between 0.026 and 0.042 rad. The hourly mean σϕ is higher during the period of high solar activity. The findings can be attributed to the increase of solar activity from July 2013 to June 2014 with a sunspot number (SSN) that ranges from 37 to 103. These results are compared with the solar activity from July 2007 to June 2008 with SSN ranging from 1 to 10.

14:40 *Study on Extension to Higher Frequency Band of 3GPP Outdoor-to-Indoor Path Loss Model*
Tetsuro Imai and Koshiro Kitao (NTT DOCOMO, INC., Japan); Nobutaka Omaki (NTT DOCOMO INC., Japan); Yukihiko Okumura (NTT DOCOMO, INC., Japan)
Recently, mobile communication system for the 5th generation (5G) has been extensively investigated to satisfy the need for high-speed and high-capacity communication. In order to realize the higher and larger data communication, one of the approaches is to utilize high frequencies such as high SHF (above 6 GHz) and EHF (30 - 100 GHz). These frequency bands are expected to be applied for outdoor or indoor small cell; hence it is critically important to investigate the characteristics of propagation and model it. Additionally, characteristics of 'Outdoor-to-Indoor (O2I) propagation' and its modelling are necessary from system design point of view. This report presents extensive investigation for "Extension of 3GPP model below 6 GHz".

15:00 *Statistic Properties of Rainfall in Tokyo for Millimeter-Wave Wireless Network - Rain Duration Analysis -*
Takuichi Hirano, Jiro Hirokawa and Makoto Ando (Tokyo Institute of Technology, Japan); Riichiro Nagareda and Akira Yamaguchi (KDDI R&D Laboratories Inc., Japan); Hitoshi Nagahori and Toru Taniguchi (Japan Radio Co., Ltd., Japan)
Statistic properties of rainfall in Tokyo are presented in this paper. Average rain duration as a function of rain rate is analyzed for future route switching technique to increase network availability. In case of strong rain (>100 mm/h), minimum and maximum duration were 20 sec. and 335 sec., respectively. It was found that even in the campus within 1 km, rain rate is different at each site and rain rate is 40 % - 70 % at another site in case of strong rain.

S5.11: RFID and wireless sensing II

Room: Auditorium

Chairs: Nemai Karmakar (MONASH University, Australia), Konstanty S Bialkowski (The University of Queensland & National ICT Australia, Australia)

13:00 *Diversity Reception of 920MHz RFID Reader Antenna in Smart-Shelf System*
Kuan-hua Chen and Qiang Chen (Tohoku University, Japan); Kunio Sawaya (Tohoku University & School nof Engineering, Japan); Machiko Oouchida and Yoshiaki Hirano (Teijin Limited, Japan)
A two-dimensional communication sheet is used as a receiving antenna of a smart-shelf system. Radio frequency identification (RFID) is the protocol used in this system to read the tag which includes information of the goods on the smart-shelf system. In this report, the diversity reception which is switching the termination condition between open and short circuits is proposed to improve the electric field intensity in the low sensitivity area and the simulation and experimental results are shown.

13:20 *Design and Feasibility Analysis of Conventional Planar Antennas as Chipless RFID Strain Sensors*
Shuvashis Dey (Monash University, Australia); Nemai Karmakar (MONASH University, Australia)
This paper focuses on the design and feasibility analysis of conventional planar antennas as chipless RFID strain sensors. A number of printed monopole and dipole antennas are designed and their structural deformation due to different types of applied strain is theoretically analyzed. This theoretical deformation results are used to calculate the corresponding resonance frequency and quality factor deviation to determine the maximum amount of strain the antennas can handle. Thus a novel analysis is presented to determine the acceptability of the designed antennas to be used as strain sensors.

13:40 *A Serpentine PIFA Antenna for Implantable RFID Tag*
Shahidul Islam, Karu Esselle and Khaled Mahbub Morshed (Macquarie University, Australia); Ladislau Matekovits (Politecnico di Torino, Italy); Sumyea Sabrin (Macquarie University, Australia)
A serpentine planar inverted-F antenna (PIFA) is designed for Medical Implant Communications Services (MICS) band (401-406MHz) and presented in this paper. Resonance frequency of implantable antenna is generally detuned towards lower frequency due to the proximity effect of high permittivity human tissue. In addition, biocompatible coating material on the antenna also leads frequency shifting of the antenna. To overcome this frequency detuning problem, the proposed serpentine PIFA is sealed in a high dielectric constant (Silicon, εr =11.9) material. The proposed PIFA antenna is predicted to be functional in MICS band under IEEE standard safety regulation. Gain of the antenna is -33dBi.

14:00 *Propagation Modelling of RFID Systems for Road Monitoring Applications*
Konstanty S Bialkowski and Amin Abbosh (The University of Queensland, Australia)
Monitoring of vehicles on roads and tunnels is performed with the use of RFID tag technology. Unfortunately, the reliability of the current RFID-based approaches is lacking. This paper explores the possible reasons for this by performing a propagation study. Also, a possible alternative that mitigates these problems is presented, which can also allow lower cost RFID tags to be used for the road monitoring applications. Reducing the cost and increasing the reliability can allow for more ubiquitous monitoring which in-turn can allow more informed decisions to be made on future road, bridge and tunnel infrastructure.

14:20 *MUETSenses: A Wireless Sensor Network Based Indoor Environment Monitoring System*

Javed Baloch (Mehran University of Engineering & Technology, Pakistan); Saira Ahmed, Sikandar Shigri and Jalil Bhatti (Mehran University Of Engineering And Technology Jamshoro, Pakistan)

A novel approach to the design of a Wireless Sensor network (WSN) based indoor environment monitoring system, which parses data in real time, on demand and periodically is presented. The aim of this system is to monitor indoor environment remotely, through an android application. The system comprises of Crossbow Iris motes, MTS 400 Sensor board, MIB 520 data accusation board designed by UC Berkley and Intel, and a base station to monitor environmental parameters such as temperature, pressure, humidity and light. The system exploits mote view software to acquire data from the wireless sensors network. At the back-end, a database has been developed to load the data from mote view and the system pushes data from the database to an android application designed for the system. The system enables users to monitor the indoor environment parameters on their android smartphones.

14:40 *Null Mitigation of Planar RFID Tag Antennas*

Sika Shrestha (Monash University, Australia); Nemai Karmakar (MONASH University, Australia)

Printed monopole and dipole antennas for RFID tags have inherent nulls in their radiation patterns. These nulls in radiation patterns limit tag reading even if a circularly polarized reader antenna is used. The paper presents ten various conventional and novel printed antennas to improve the nulls for maximum visibility of the tag. The investigation reveals that highest null improvement of 25 dB in monopole and 24.6 dB in dipole is possible using non-conventional monopole and dipole.

15:00 *A Wideband Capacitively Fed Suspended Plate Antenna for Wearable Wireless Sensors*

Mohammad Vatankhah Varnoosfaderani (Griffith University & Center for Wireless Monitoring and Application, Griffith University, Australia); David V Thiel and Junwei Lu (Griffith University, Australia)

A suspended shorted patch capacitively fed using an inverted L-shape feed is a compact antenna for wearable wireless sensors. A short microstrip line was printed on the sensor PCB to connect the antenna to a transceiver chip. The shorting of the suspended patch was done using printed silver ink on the side wall of a 22mm x 6mm x 6mm block of polycarbonate plastic that suspends the mounted patch. Based on the required bandwidth, the height of the plastic block can be decreased to 2 mm. The simulated 10 dB bandwidth of the antenna, was 98% (2.2 GHz-6.44 GHz) for a 6 mm high polycarbonate block. The size of the sensor including the elevated antenna was 35mm x 22mm x 9mm. The antenna features an upward directional radiation pattern which decreases the electromagnetic coupling between the human body and the antenna.

15:40 - 18:00

S1.12: Radar and satellite systems II

Room: Tasman A

Chairs: Yijun Feng (Nanjing University, P.R. China), Masahiko Nishimoto (Kumamoto University, Japan)

15:40 *Parametric Representation of Radar Target Responses*

Masahiko Nishimoto (Kumamoto University, Japan)

This study describes parametric representation of radar target responses and its physical interpretation. Under a high frequency approximation, a transfer function of a scattering system is factorized into three elementary parts, and a target response with three parameters that are related to a local shape at a scattering center is derived. In order to use these parameters for radar target identification, a relationship between the parameters and the response waveform is discussed.

16:00 *Evaluation of High-Speed FMCW Signal Generation and Processing for Optically-Connected Distributed-Type Millimeter-Wave Radar*

Shunichi Futatsumori, Kazuyuki Morioka, Akiko Kohmura, Kunio Okada and Naruto Yonemoto (Electronic Navigation Research Institute, Japan)

The optically-connected distributed-type millimeter -wave radar system has been proposed and developed to detect small debris on the airport surface. The key concept of the radar system is the distributed architecture which consists of a single central unit and several antenna units, where both units are connected by radio-over-fiber technology. In this paper, the advantages of the architecture are experimentally evaluated using the prototype 96 GHz radar system. Firstly, a high-speed 12 GS/s arbitrary waveform generator-based frequency-modulated continuous wave signal generation is discussed. Then, the effects of the 10 kHz FM chirp rate is confirmed in a radar reflectors detection test at Sendai Airport.

16:20 *Wideband Microwave Radar Cross Section Reduction by Orientation Distributed Digital Metasurfaces*

Ke Chen, Junming Zhao and Yijun Feng (Nanjing University, P.R. China)

This paper presents a novel design of orientation distributed digital metasurface aiming at suppressing backward radar cross section (RCS) within a broad working bandwidth. A corrugated meander line structure is proposed as the constitutive unit cell that is capable of creating 1-bit (with two orientations of 0 and 90 degree), 2-bit (with four orientations of 0, 45, 90 and 135 degree) and multi-bit elements by different orientations with respect to the geometric center. Each digital element shows a different reflection phase response to the incident electromagnetic (EM) waves, thus the metasurface designed by two dimensional disordered distribution of the digital elements will have randomly distributed phases shifts at the interface, leading to a diffusion of backward EM scattering. Thereby, the monostatic RCS is substantially suppressed. The broadband performance of the proposed metasurface has been verified through full wave simulations.

16:40 *DVA-C_a Chinese Dish Prototype for SKA*

Biao Du and Yuanpeng Zheng (JLRAT, P.R. China); Yang Wu (Joint Laboratory of Radio Astronomy Technology, P.R. China); Xiaoming Chai, Yifan Zhang, Bin Liu, Guoxi Liu, Long Chen and Lei Yu (JLRAT, P.R. China); Chengjin Jin (National Astronomical Observatories, Chinese Academy of Sciences, P.R. China); Xiang Zhang, Di Wu and Bo Peng (JLRAT, P.R. China)

The Square Kilometer Array (SKA) has now entered into the pre-construction phase, A hundred of institutes in about 20 countries including China have been involved in its key technology development. The Dish Verification Antenna China (DVA-C) is a prototype being built to farthest meet the requirements from the SKA scientific goals, with unique skin-and-rib structure single-piece panel reflectors. In this paper, design of DVA-C is presented, including optical design, dish structure, and servo. The measured electromagnetic and structural performances, as well as preliminary observational results are provided.

17:00 *Direction of Arrival Estimation in FDTD Analysis of Radio Propagation Using MUSIC Method*

Suguru Imai, Kenji Taguchi and Tatsuya Kashiwa (Kitami Institute of Technology, Japan)

In the ray-tracing method, radio propagation is approximately represented by using reflected and diffracted rays. Thus an arrival angle of incoming wave can be known easily by using the path of ray. On the other hand, in the FDTD method, a propagation wave is calculated strictly based on Maxwell's equations. Therefore, it seems difficult to know the arrival angle of incoming wave in the FDTD analysis. However, it is expected that the arrival angle of incoming wave can be obtained by using the direction of arrival estimation method in the FDTD analysis. In this paper, the direction of arrival estimation in the FDTD analysis of radio propagation using the MUSIC method is investigated.

17:20 *Harmonic Radar Transponder for Microsensing Systems*

Andrew R Weily, Diethelm Ostry and Mark E Johnson (CSIRO, Australia)

A harmonic transponder design suitable for microsensing systems is presented. The transponder is a passive device and operates at millimeter-wave frequencies to reduce its size and weight. The receive band is 38-38.5GHz and the transmit band is 76-77GHz. The transponder is formed from two planar microstrip patch antennas and a frequency multiplier circuit, and its minute size and weight make it an attractive option for tracking small objects or animals.

17:40 *Optimal Cross-Range Pattern Synthesis Using Multi-Objective Genetic Algorithm for a Passive Antenna in Small Satellite SAR*

Vinay Ravindra (University of Tokyo, Japan); Hirofumi Saito (Institute of Space & Astronuatical Science Japan, Japan); Prilando Akbar (Institute of Space and Astronautical Science/ Japan Aerospace Exploration Agency, Japan); Miao Zhang and Jiro Hirokawa (Tokyo Institute of Technology, Japan)

In synthetic aperture radar application imaging image artifacts due to azimuthal ambiguity, non-smooth noise equivalent sigma zero are common. They can be controlled to a certain extent by synthesizing the appropriate antenna pattern in cross-range plane. Our small satellite mission "microXSAR" carries a X-Band SAR instrument as payload, with a passive waveguide fed SAR antenna. In this paper we describe the synthesis of the cross-range pattern of the SAR antenna by treating it as a multi-objective optimization problem. We use non-dominated sorting algorithm NSGA-II as the optimization algorithm. The result is a pareto-curve giving all possible non-dominated solutions.

S2.12: Diversity and MIMO

Room: Tasman B

Chairs: Sungtek Kahng (University of Incheon, Korea), Weidong Wang (Beijing University of Posts and Telecommunications, P.R. China)

15:40 *Miniaturized Dual-Layers LTE MIMO Printed Antenna with Hybrid Decoupling Elements to Improve Isolation*

Ding-Bing Lin, Chih-Yu Wu, Cheng-Hsien Sung and Pei Wei Lin (National Taipei University of Technology, Taiwan)

A miniaturized multilayer internally multiple-input multiple-output (MIMO) printed antenna system combined with hybrid decoupling elements to improve isolation between two antennas at triple Long-Term Evolution (LTE) bands is presented in this paper. To reduce the single antenna size, the meander lines are stretched perpendicularly on the two respective layers that its overall dimensions are 14 × 15 × 3.2 mm^3. Two different mechanisms are introduced for enhancing the port isolation at two different frequency bands. The isolation within three desired bands could be improved to all below -20 dB.

16:00 *Simple Channel Capacity Evaluation of MIMO Antenna Using Small Reverberation Chamber*

Ryuya Seki, Naoki Honma and Yoshitaka Tsunekawa (Iwate University, Japan)

For multiple-input multiple-output (MIMO) antenna evaluation, over-the-air (OTA) performance testing is commonly conducted using fading emulator and reverberation chamber. However, such conventional approaches require huge and expensive measurement setups, and therefore, the simplification of the evaluating system configuration is a key challenge. In this paper, we propose a novel channel capacity evaluation method using a small reverberation chamber and only one-side MIMO antenna. In the proposed method, first, S-parameters of an evaluated MIMO antenna are measured in both free-space and a reverberation chamber. Then, scattering wave components are equivalently extracted by subtracting the former S-parameter from the latter. Finally, channel capacity is evaluated regarding the extracted scattering components as pseudo multipath-rich propagation channels. From experimental results, it is confirmed that the channel capacity characteristics obtained by the proposed method has a good agreement with that of 3D-uniform ring model.

16:20 *Comparison of 2-bitstream Polarization-MIMO Performance of 2 and 4-port Bowtie Antennas for LTE in Random-LOS*

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

We evaluate the performance of a dual-polarized wideband antenna in terms of polarized-MIMO in Random-LOS for two different modes of operation: 2 and 4-port excited mode. The 2-port mode was obtained by differential excitation of two opposite ports of the 4-port design by using two baluns. The Zero-Forcing receiver throughput is evaluated based on the Probability of Detection of two bitstreams when orthogonal polarizations provide the MIMO subchannels. Assuming a uniform distribution for the Angle of Arrivals and orthogonally polarized waves incident on the antennas, the overall PoD over coverage cones of 30°, 60° and 90° are presented. The 2-bitstream multiplexing MIMO efficiency defined at the 95% Probability of Detection is evaluated for the two modes of operation at different frequencies and for different coverage cones. The 2-bitstream coverage pattern of the antenna for the two modes are plotted versus the range of Angles-of-Arrival (AoA), by choosing fixed polarization (horizontal and vertical) for incoming waves.

16:40 *Design of a Dual-Band LTE MIMO Antenna to Be Embedded in Automotives*

Jinsu Jeon and Hyunsu Kim (Incheon National University, Korea); Muhammad Kamran Khattak (Incheon National University & Ghulam Ishaq Khan Institute of Technology, Korea); Sungtek Kahng (University of Incheon, Korea)

A dual-band MIMO antenna is designed for automotive-based LTE communication. Basically, a monopole antenna is modified to resonate at a 900-MHz LTE band and a 1.9-GHz area, and to occupy a small real estate. Due to the dual-band resonance and radiation as one physical body, when this antenna is extended to the MIMO structure, the overall volume is relatively small to fit the space under the navigation monitoring box of a car. The design shows the antenna gain over 1 dBi and the return loss below -10 dB for the two LTE bands

17:00 *On the 3-D MIMO Channel Model Based on Regular-Shaped Geometry-Based Stochastic Model*

Jiali Chen (Beijiing University of Posts and Telecommunications, P.R. China); Shuang Wu (Beijing University of Posts and Telecommunications, P.R. China); Shuaijun Liu (Beijing University of Posts and Telecommunications & Information and Technology Lab, School of Electronic Engieering, P.R. China); Chaowei Wang (Beijing University of Posts and Telecommunications & Schoole of Electronics Engineering, P.R. China); Weidong Wang (Beijing Unversity of Posts and Telecommunications, P.R. China)

This paper proposes a novel three-dimension multiple-input multiple-output (MIMO) channel model based on Regular-Shaped Geometry-Based Stochastic Model (RS-GBSM), which is called Geometrical Multi-Ellipsoid Based Stochastic Model (GMEBSM). Scatterers are assumed to be distributed on the surface of the ellipsoids whose foci are at the center of transmitter and receiver ends. Ellipsoids with different propagation delays are assumed to obey exponential distribution. By using the von Mises Fisher (VMF) distribution, the proposed model has the ability to jointly consider the azimuth and elevation angles. Assuming in 3-D non-isotropic scatting model, the expression for the space-time correlation function (STCF) between each two sub channels is derived. Finally, simulation results of the derived CF are presented.

17:20 *Performance Evaluation of SVD-MIMO-OFDM System with a Thinned-out Number of Precoding Weights*

Kazuhiko Mitsuyama and Takashi Kumagai (Japan Broadcasting Corporation, Japan); Naohiko Iai (Japan Broadcasting Corporation (NHK), Japan)

We are designing system parameters for manufacturing a prototype SVD-based 4x4 MIMO-OFDM system with our adaptive bit and power allocation (ABPA) algorithm. Designing the parameters at the cost of a minimum amount of feedback is important to achieve high spectral efficiency in time division duplex (TDD) systems. We constructed a performance evaluation system for the SVD-based MIMO system and evaluated the bit error rate (BER) performances when the number of precoding weights fed back was thinned out under three MIMO channel models with different delay spreads. The measurement results demonstrated that the amount of feedback can be reduced by one eighth in the model with the largest delay spread, keeping BER performance degradation.

S3.12: Microwave and RF devices II

Room: Tasman C

Chairs: Muhammad Fasih Uddin Butt (COMSATS Institute of Information Technology, Islamabad, Pakistan), Mariana Nikolova Georgieva-Grosse (Meterstrasse 4, Germany)

15:40 *Prototype Evaluation of a Beam Tracking Antenna Using Magic-T*

Rimi Rashid, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

In this paper, a new beam tracking antenna is proposed. It consists of a magic-T circuit, two antenna elements and two phase shifters and brings a new prototype antenna in wireless communication systems. The main idea for the antenna is to shift the beam by adjusting the phase shifter using the difference of signals received by the two antenna elements. Both-sided MIC technology is effectively used to integrate the magic-T and phase shifters with a simple structure. Radiation pattern and return loss are measured and this concept is experimentally demonstrated.

16:00 ***Effect of the Material and Geometry Parameters on the Differential Phase Shift in the Circular Waveguide, Containing a Ferrite Cylinder with Azimuthal Magnetization and a Dielectric Toroid***

Mariana Nikolova Georgieva-Grosse (Meterstrasse 4, Germany); Georgi Nikolov Georgiev (University of Veliko Tirnovo "St. St. Cyril and Methodius", Bulgaria)

The influence of the material and geometry parameters on the differential phase shift, afforded by the circular waveguide with an azimuthally magnetized co-axial ferrite cylinder and a dielectric toroid, is studied for normal TE01 mode, provided the relative permittivity of the isotropic layer is larger than that of the anisotropic one. An iterative technique is used, employing the positive purely imaginary roots of the characteristic equation of the structure, derived by complex Kummer and real cylindrical functions, determined, varying the imaginary part of the complex first parameter of the Kummer ones. The outcomes are presented in normalized form tabularly and graphically and are debated. It is established that for certain values of the parameters of guiding line the phase shift increases, compared to the case in which the permittivities of both media are equal, considered earlier. Simultaneously, the area in which it might be produced, narrows.

16:20 ***A General Design Method for Band-pass Post Filters in Rectangular Waveguide and Substrate Integrated Waveguide***

Cheng Zhao (University of Adelaide, Australia); Christophe Fumeaux (The University of Adelaide & School of Electrical and Electronic Engineering, Australia); Thomas Kaufmann (The University of Adelaide, Australia); Yingbo Zhu (University of Adelaide, Australia); Ali K. Horestani (The University of Adelaide, Australia); Cheng-Chew Lim (University of Adelaide, Australia)

This paper presents an efficient design approach for band-pass post filters in waveguides, based on mode-matching technique. With this technique, the characteristics of symmetrical cylindrical post arrangements in the cross-section of the considered waveguides can be analyzed accurately and quickly. Importantly, the approach is applicable to post filters in waveguide but can be extended to Substrate Integrated Waveguide (SIW) technologies. The fast computations provide accurate relationships for the K factors as a function of the post radii and the distances between posts, and allow analyzing the influence of machining tolerances on the filter performance. The computations are used to choose reasonable posts for designing band-pass filters, while the error analysis helps to judge whether a given machining precision is sufficient. The approach is applied to a Chebyshev band-pass post filter and a band-pass SIW filter with a center frequency of 10.5GHz and a fractional bandwidth of 9.52% with verification via full-wave simulations using HFSS and measurements on manufactured prototypes.

16:40 ***Compact Ultra-Wideband Balun Filter and Its Quasi- Yagi Antenna Application***

Li Yang (Faculty of Science and Technology, University of Macau, Macao); Wai Wa Choi (University of Macau, Macao); Kam Weng Tam (University of Macau, P.R. China)

In this paper, a compact quasi-Yagi antenna with ultra-wideband balun filter is presented. The proposed balun filter is constructed with composite microstrip and slotline resonators. With the excited three resonant modes of slotline resonator and two additional resonant modes of microstrip lines, the balun filter with ultra-wideband response can be realized. Thus, with this proposed ultra-wideband balun filter, the designed quasi-Yagi antenna presents an impedance bandwidth from 5.95 to 10.76 GHz with return loss |S11| > 10 dB.

17:00 ***Parallel-Coupled Line Bandpass Filter Design Using Different Substrates for Fifth Generation Wireless Communication Applications***

Nadera Najib Al-Areqi (Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Malaysia); Norhudah Seman (Universiti Teknologi Malaysia, Malaysia); Tharek Abdul Rahman (Wireless Communication Centre, Malaysia)

The aim of this paper is to propose characterization of a compact microstrip bandpass filter (BPF) design for fifth generation (5G) wireless communication applications. The BPF design consists of quarter wave parallel-coupled line resonators and additional small resonator attached between the first/last coupled-line section and the ports' 50 ohm transmission line. The characterization is based on the analysis of different substrates with the selected relative permittivity of 2.2 (RT/Duroid 5880), 3.55 (RO4003C), 4.70 (TMM4), 10.7 (RO6010) and 11.20 (RO3010). The proposed design with substrate RO6010 exhibits improvement in the bandwidth performance with the center frequency of 15 GHz. The design and analysis are performed via the use of Keysight's Advanced Design System (ADS) 2015 simulator.

17:20 ***Miniaturized Directional Filter Multiplexer for Band Separation in UWB Antenna Systems***

Jakub Sorocki, Ilona Piekarz, Slawomir Gruszczynski and Krzysztof Wincza (AGH University of Science and Technology, Poland)

In this paper, new design of miniaturized coupled-line directional filter multiplexer allowing for band separation in UWB antenna systems has been proposed. To achieve small size of the directional filters, hence entire multiplexer, directional couplers constituting the filter have been miniaturized following the approach, in which the coupler is realized as a connection of tightly coupled and uncoupled lines. Moreover, sections of quarter-wave-long transmission lines have been designed with quasi-lumped elements approach, which allows for further miniaturization of the structure. Theoretical analysis of the circuit has been provided. Moreover, performance of the presented approach has been verified by the design and measurement of an exemplary single directional filter multiplexer covering ISM 2.4 GHz band.

17:40 ***Parametric Analysis of a Band-Pass FSS for Double Glazed Soft-Coated Energy Saving Glass***

Shahid Habib (COMSATS Institute of Information Technology, Islamabad & Telenor Pakistan, Pakistan); Muhammad Fasih Uddin Butt (COMSATS Institute of Information Technology, Islamabad, Pakistan); Ghaffer Kiani (King Abdulaziz University, Jeddah, Saudi Arabia)

Parametric analysis of a band-pass FSS for double glazed soft-coated energy saving glass is presented. An aperture type hexagonal FSS is etched in the coating to improve transmission of useful RF/MW signals which is attenuated due to its presence. It provides a transmission improvement of up to 20 dB in the band of 0.1 GHz to 2.3 GHz (-10dB bandwidth of 2 GHz). The amount of area etched due to aperture is minimized to avoid heat loss. Parameters such as glass dielectric constant, coating impedance and aperture width are varied to get optimal solution. More than 10 dB and 25 dB attenuation is obtained at 2.45 GHz and 5.25 GHz, respectively, to ensure WLAN security for an indoor environment. Theoretical results for TE and TM polarizations are presented for normal and oblique incidence.

S4.12: EBG, metamaterials and periodic structures II

Room: Wellington

Chairs: Ananjan Basu (Indian Institute of Technology, Delhi, India), Gregory N Milford (University of New South Wales, Australia)

15:40 *A Partial-Reflective-Metasurface-Based Fabry-Pérot Cavity Antenna*

Jiaran Qi, Shanshan Xiao and Chang Liu (Harbin Institute of Technology, P.R. China)

A Fabry-Pérot cavity antenna with extended 3dB gain bandwidth is presented in this paper. The proposed structure consists of a rectangular-patch microstrip antenna, on top of which a planar partial reflective surface (PRS) is mounted. Two periodic planar structures, i.e. metasurfaces, with different unit cells are printed on both sides of a 1.5mm-thick Rogers 5880 substrate, forming a novel PRS. It is then confirmed by simulation and experimental results that the proposed antenna operates at around 12GHz with a relative bandwidth of 19.77%. The measured gain can reach 16dB with a 3dB gain bandwidth of 11.23%, much more than a Fabry-Pérot Cavity antenna with a traditional PRS.

16:00 *A Composite EBG Resonator Antenna with a Sparse Array Feed*

Affan Baba, Raheel Hashmi and Karu Esselle (Macquarie University, Australia)

In this paper, we study performance of a simple electromagnetic band gap (EBG) resonator antenna (ERA) that has a composite all-dielectric superstructure and is excited by a small sparse array. The cavity of the antenna is excited by a 2x2 array of waveguide fed slots with an inter-element spacing of 1.80. The ERA exhibits high gain with an excellent directivity bandwidth of around 20%. The proposed configuration provides improved performance in terms of antenna gain and directivity bandwidth, while significantly minimizing design complexity. Numerical results are presented and a peak gain of 21 dBi is demonstrated.

16:20 *Experimental Investigation on High Efficiency Decoupling Using Tunable Metamaterials*

Liang Zhang, Zhengyong Song, Longfang Ye and Yanhui Liu (Xiamen University, P.R. China); Qing Huo Liu (Duke University, USA)

More than 110 dB isolation is experimentally realized in a narrow band in this work. Multiple varactors based tunable metamaterials were placed between two co-polarized monopole antennas. The metamaterials are controlled using an genetic algorithm (GA) based optimization program. The optimization goal is to minimize the transmission coefficient of a . After 3000 generations of evolution, more than 110 dB isolation ratio is achieved. This method is verified by two experiments with different metamaterial structures.

16:40 *Magnetic Resonance Type Selective Wireless Power Transfer Using Two Transmission Resonators with Phase Difference*

Yoshihiro Fukushima, Eisuke Nishiyama and Ichihiko Toyoda (Saga University, Japan)

Recently, a magnetic resonant wireless power transfer technology has been attracting much attention due to its superior power transfer performance in a middle distance. As the technology utilizes the resonance phenomenon of a magnetic field, unintentional resonators with the same resonant frequency cause a power leak. In this study, a new selective wireless power transfer system using two transmission resonators with phase difference is proposed and experimentally examined. The proposed concept was found to be feasible.

17:00 *Comparative Study and Analysis of High Permittivity and Low Permittivity Continuous Phase Correcting Structures for EBG Resonator Antennas*

Muhammad Usman Afzal and Karu Esselle (Macquarie University, Australia)

This paper presents low-profile continuous phase correcting structures (PCS) for conventional electromagnetic bandgap resonator antennas (ERAs). This PCS has been implemented using a relative high-permittivity-dielectric material and is compared with a low-permittivity Rexolite PCS reported previously. The use of high permittivity materials is not advisable for the PCS design as it increases reflections from the input surface of the PCS; a PCS is supposed to be highly transmitting structure. However, it was found that if a high-permittivity-dielectric PCS is placed above ERA with a proper spacing then high reflections can be used to an advantage. Overall peak directivity of an ERA with TMM4 PCS is 1 dB more than that of the Rexolite PCS along with 44% reduced height profile.

17:20 *Analysis of Nonlinear Left-Handed Transmission Lines Using State Space Modelling*

Sameh Y Elnaggar and Gregory N Milford (University of New South Wales, Australia)

We demonstrate the use of state space modelling for analysing parametric generation in nonlinear composite right left handed transmission lines. The system natural frequencies are identified and found to be comparable to the linearized system dominant poles. With an input pump excitation, the structure generates parametric frequency components, and the state space analysis suggests that the parametric frequencies are determined by the dominant poles of the linearized system. The growth of the parametric components depends on the net effect of the energy transfer from the pump and the structure dissipative nature. It is found that below a threshold value of the pump amplitude, the parametric components are inhibited. This value is a function of the pump frequency and the structure losses. The numerical calculations are in good agreement with measurements. State space formulations allow the application of the mature and robust techniques of systems and control methodologies to analyse the behaviour of nonlinear right left handed transmission line systems.

17:40 *Multi-layer FSS for Gain Improvement of a Wide-Band Stacked Printed Antenna*

Shashibhushan Kumar (IIT Delhi, India); Lalithendra Kurra (Indian Institute of Technology Delhi, India); Mahesh Abegaonkar (IIT Delhi, India); Ananjan Basu (Indian Institute of Technology, Delhi, India); Shiban K Koul (Indian Institute of Technology Delhi, India)

In this paper, an attempt has been made to improve the gain of a wide-band antenna using two layers of frequency-selective surfaces. It is seen that using two layers it is possible to achieve flat transmission characteristics over a reasonable bandwidth. However with an actual antenna, the gain improvement has at present been achieved over only a small band. It is expected that with further optimization and possibly increasing the number of layers, wide-band gain enhancement can be achieved.

S5.12: Diverse antenna applications

Room: Auditorium

Chairs: Nemai Karmakar (MONASH University, Australia), Peiyuan Qin (University of Technology, Sydney, Australia)

15:40 *A Position Estimation Method Based on Position Fingerprint Using Directional Antennas*

Ryo Yamada, Hisato Iwai and Hideichi Sasaoka (Doshisha University, Japan)

In this paper, we consider a position estimation method based on propagation characteristics of multipath fading. In the method, prior to the actual position estimation, we need to measure propagation characteristics at known positions and build a database (DB). Using DB, we estimate a terminal position based on the similarity of the propagation characteristics of the DB positions and the terminal position. We propose to adopt directional antennas for the position estimation. In this paper, we evaluated the accuracy of the proposed method quantitatively via computer simulations. As a result of the evaluation, we found it is possible to estimate the position more accurately with less number of pre-measurement by adopting directional antennas than the conventional method.

16:00 *Ka-band Complementary Reflector Backed Slot Antenna Array for Soil Moisture Radiometer*

Muhsiul Hassan and Shuvashis Dey (Monash University, Australia); Nemai Karmakar (MONASH University, Australia)

This paper presents a high gain 4×4 slot antenna array designed to operate in Ka-band (in this case 35-40 GHz) as a soil moisture radiometer. Simulation result with measurement are presented for the slot antenna array. The main hind sight of a slot antenna is the radiated back lobe which can be improved using a reflector. A complementary patch array reflector is used to suppress back lobe radiation in simulation. Comparison of simulation as well as measurement with and without back-reflectors are discussed. Radiation patterns and different side lobe levels for different frequencies are justified.

16:20 *Indoor Real-time Multiple Moving Targets Detection and Tracking Using UWB Antenna Arrays*

Shengchang Lan and Caitian Yang (Harbin Institute of Technology, P.R. China); Beijia Liu (Harbin Institute of Technology & School of Electronics and Information Engineering, P.R. China); Jinghui Qiu and Alexander Denisov (Harbin Institute of Technology, P.R. China)

The paper describes an approach of indoor multiple moving target detecting and tracking by using Ultra Wide band (UWB) signals. The approach utilizes estimating the time of arrival(TOA) of the 26GHz bandwidth UWB pulses from transmitted to received through a linear antenna array, providing a real-time computation of moving targets position in X-Y plane. The results of the proposed approach show a reliable and responsive performance in monitoring the indoor multiple targets motions.

16:40 *Wideband Marchand Balun and Bow-tie Antenna for Sensor Aplications*

Ilona Piekarz, Jakub Sorocki, Krzysztof Wincza and Slawomir Gruszczynski (AGH University of Science and Technology, Poland)

A novel wideband Marchand balun and bow-tie antenna have been proposed for sensor application. The proposed balun has been designed to differentially fed bow-tie antenna and match its differential impedance. The proposed approach has been investigated and verified by electromagnetic calculations and measurements of an exemplary Marchand balun and bow-tie antenna operating at center frequency f0 = 1 GHz. The obtained simulation and measurement results prove the usefulness of the proposed approach for utilization as sensor for healthcare application.

17:00 *A Study of Passive Aircraft Surveillance Using Signal Delay Profile*

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

The current Air Traffic Management (ATM) uses various radio equipment. The radar is the one of important system and the recent ATM uses a combination of several radar systems. However, the conventional Primary Surveillance Radar have a high cost of maintenance and operation. Recently, Multi-Static Primary Surveillance Radar (MSPSR) has attracted interest from the civil aviation research field. The MSPSR is classified into passive bistatic radar (PBR). In this paper, we show the experimental results of aircraft positioning using signal delay profile and we describe the potential of the aircraft surveillance using our proposed method.

17:20 *SAR Reduction of Helmet Antenna Composed of Folded Dipole with Slit-Loaded Ring*

Naoto Nishiyama, Naobumi Michishita and Hisashi Morishita (National Defense Academy, Japan)

Helmet antennas have been investigated for various applications, such as military, construction, and disaster prevention. In their radio system operated at the low frequency, the half wavelength circular loop antenna, the folded dipole antenna, and the inverted-F antenna have been proposed. Since these antennas are arranged in proximity to the human head, the radiation efficiency is reduced and the value of the specific absorption rate (SAR) increases. To reduce the unwanted radiation toward the human head, the installation of the conductor ring is effective. This paper presents the further improvement of the radiation efficiency and the reduction of the SAR value by loading the slit to the conductor ring. The relative bandwidth of 1.0%, radiation efficiency of 44.0%, gain of −3.7 dBi, and the 10 g average local SAR of 0.22 W/kg are obtained with the conductor ring.

17:40 *Quantification of Degree-of-Order in Urban Area From Full-Polarimetric SAR Observation*

Hajime Fukuchi, Shota Tsuchida and Teruki Nezato (Tokyo Metropolitan University, Japan)

It is known that orientation angle of man-made objects such as aligned buildings can be estimated from an argument value of complex correlation coefficient of circularly polarized synthetic aperture radar(SAR) measurement bases. To utilize such feature, degree-of-order in urban area is defined quantitatively as dispersion of the argument which is called polarization angle(PA) derived from full-polarimetric SAR measurements. We estimated the degree-of-order from PALSAR and PiSAR2 full-polarimetric measurements at several areas including natural vegetation or tree area and aligned building filled one. To derive dispersion of angle data, we adopted 'unit vector sum' method to avoid ambiguity effect of angle data. The dispersions at natural vegetation areas are larger than those at orderly aligned building areas. Then proposed dispersion is regarded as quantitative degree-of-order measure.

