2010 International Workshop on Antenna Technology

(iWAT 2010)

Lisbon, Portugal
1-3 March 2010

SS1: **Body-Centric Antennas**

Chairs: Koichi Ito (Chiba University, Japan), Peter Hall (University of Birmingham, United Kingdom)

(SS1.1) **9:10 Electric Field Distributions Around the Human Body Generated by a Small Wearable Antenna (Keynote) @! 3**

Koichi Ito (Chiba University, Japan)

Frequencies used for body-centric wireless communications widely range from MHz to GHz. In this paper, to bring objective and unified idea on the frequency dependence, electric field distributions around
the human body wearing a small antenna in a range of 2.5 MHz to 2.5 GHz are numerically calculated. Then, influences of the ground as well as different posture of the human body on the electric field distributions are numerically investigated. Finally, calculated results of some useful parameters at HF
band are demonstrated for a practical situation of touching a receiver attached to the wall near the security door.

(SS1.2) **9:40 Link Budget Analysis and Characterization for Ingestible Capsule Antenna #**

Yahya Rahmat-Samii (University of California Los Angeles (UCLA), USA); Harish Rajagopalan (University of California Los Angeles (UCLA), USA).

This paper characterizes and analyses the link budget requirements for the conformal capsule antenna in the medical capsule imager system. A link budget is developed for the capsule system based on certain parameters (frequency, SAR power limitations) and it is shown that using the present antenna system; a reliable communication link can be developed for indoor communication for bio-telemetry applications. The polarization diversity exhibited by the conformal capsule antenna is tested and compared to simple dipole design. Due to diverse polarization, a reliable link is obtained irrespective of the capsule location and orientation and this study is discussed in detail.

(SS1.3) **10:00 Multiple Antenna Systems for Increasing On-Body Channel Capacity and Reducing BAN-to-BAN Interference '**

Imdad Khan (University of Birmingham, United Kingdom); Peter Hall (University of Birmingham, United Kingdom); Yuriy I. Nechayev (University of Birmingham, United Kingdom); Lida Akhoondzadeh-Asl (University of Birmingham, United Kingdom)

The application of multiple-input multiple-output (MIMO) in body-area networks (BAN) is considered in the paper. The correlations between MIMO sub-channels and the MIMO channel capacity are investigated for three on-body channels when random movements are performed in an indoor environment. Some of the MIMO sub-channels were found to be correlated. Nevertheless, a significant capacity increase due to use of MIMO was still observed thus demonstrating the feasibility of using MIMO in 1428B1424BBAN communications. A simple BAN-to-BAN interference rejection method which makes use of interrupted transmission is also proposed in the paper, and is shown to produce interference rejection gains significantly higher than those produced by two conventional interference rejection methods.

(SS1.4) **10:20 Dual-band Low Profile Antennas for Body-Centric Communications** +

Anupam R. Chandran (Queen's University Belfast, United Kingdom); William G. Scanlon (Queen's University Belfast, United Kingdom)

Dual-band operation is highly desirable for wearable devices that need to connect with a range of wireless systems. We present a series of microstrip-line fed, dual-band compact patch antennas designed to operate in the common 2.45-GHz and 5.8-GHz bands for body-centric communications. All of the designs are low-profile and, with further study, may be suitably implemented in flexible or fabric materials. Our best performance was obtained with a shorted parasitic patch element close to a rectangular patch operating at the TM10 mode. This design, with an overall height of less than $\lambda/24$, had a radiation efficiency of 91% at 2.45-GHz and 95% at 5.8-GHz in free space. When placed 2 mm above a muscle tissue phantom at 2.45-GHz, an efficiency of 52% and a 2:1 impedance bandwidth of 95-MHz was obtained. The bandwidth at the 5.8 GHz band was 400-MHz in free space.

SS2: Antennas on Chip and Integrated Antennas

Chairs: Ingo Wolff (IMST, Germany), Guy Vandenbosch (Katholieke Universiteit Leuven, Belgium)

(SS2.1) **11:00 Integrated Beam Steerable Antennas in LTCC-Technology (Keynote)** #%

Ingo Wolff (IMST, Germany)

Two concepts of building highly integrated beam steerable antennas for space applications are described: As a first example an integrated phased array antenna using liquid crystal phase shifters in a LTCC technology shows promising results for application in space communication. As a second example a fully integrated digital beam steering antenna in LTCC technology demonstrates how a high integration factor for a very complex antenna system including active microwave circuits and a cooling system can be realized. The design of the antennas using high sophisticated em-software, the integration and fabrication technology for producing the highly complex antenna systems are described in detail in the oral presentation.

(SS2.2) **11:30 Benchmarking of Software Tools for Small Planar Antenna Analysis** #)

Guy Vandenbosch (Katholieke Universiteit Leuven, Belgium); Alexander Vasylchenko (Katholieke Universiteit Leuven, Belgium); Walter De Raedt (IMEC, Belgium)

Within the framework of the European Network of Excellence on Antennas ACE, in 2005 the working group on software initiated a benchmarking action. At the Katholieke Universiteit Leuven this lead to a thorough investigation of six simulation tools, five well-known commercial ones and one in-house developed. They were confronted with each other for four different antennas. Two of these antennas can be considered "small antennas". It is crucial to point out that all possible efforts have been done to guarantee the most optimal use of each of the software packages, to study in detail any discrepancies between the solvers, and to assess the remaining simulation challenges. The study clearly highlights the importance of understanding EM simulation principles and their inherent limitations.

(SS2.3) **11:50 A Direct Antenna Modulation (DAM) Transmitter with a Switched Electrically Small Antenna** $#

Xiaojing Xu (UCLA, USA); Yuanxun Wang (UCLA, USA)

The first demonstration of a DAM transmitter with an electrically small antenna is presented in this paper. Traditionally efficiency-bandwidth product of an electrically small radiation system is inversely proportional to the radiation Q of the antenna, which is naturally high due to the radiation wave properties. However, a DAM transmitter integrates a switch with the small antenna so that the efficiency-bandwidth product is not limited by the radiation Q in such a time-variant system. The 1430Bkey to improve the bandwidth and efficiency simultaneously is to decouple the radiation energy from the stored energy and circulates maximum stored energy within the system. Testing results show a large bandwidth improvement over the traditional scheme, while the efficiency is not degraded significantly.

(SS2.4) **12:10 Performance Improvement of Closely Spaced Antennas Incorporating a Compensating Network $'**

Anders Derneryd (Ericsson AB, Sweden); Janne Leivo (Ericsson AB, Sweden); Anders Stjernman (Ericsson AB, Sweden); Tin Vukusic (Ericsson AB, Sweden)

This study implements a concept to reduce the effects of antenna coupling on efficiency, correlation, diversity gain, and Shannon capacity of two closely spaced (0.08 wavelengths in the upper 700 MHz band) antennas. Antenna system performance without and with different matching and compensating networks is presented. The network improves the antenna performance in terms of reduced coupling between the antennas, improved efficiency, and reduced correlation. This indicates that good receive diversity gain and MIMO Shannon capacity can be maintained in a small terminal even at the lower mobile frequency bands. The concept is finally implemented in a dual antenna mock-up with the form factor of a candy bar phone.

SS3: **UWB and Broadband Antennas**

Chairs: Xiaodong Chen (Queen Mary, University of London, United Kingdom), Yuanxun Wang (UCLA, USA)

(SS3.1)   14:00 Wideband Antenna Technology in Military Applications (Keynote) $+

Rob Lewis (BAE Systems Advanced Technology Centre, UK, United Kingdom)

Wideband antennas are an essential requirement for military systems requiring spectrum-agility or multi functionality. However, 'wideband' can refer to radiation pattern bandwidth, impedance bandwidth or both. High-gain radar or communication systems require wideband, potentially multi-octave, radiation patterns and VSWR. Low gain communication systems, particularly for mobile applications, require wideband VSWR but are tolerant of a range of radiation pattern performance. Here we describe technologies for two wideband military applications. Phased arrays in multi-function systems require wideband elements capable of wide angle scanning. The performance is critically dependent, not just on the radiating aperture, but the choice of technology and architecture performing beamforming and signal distribution behind the aperture. Body worn antennas are gaining prominence for use in military communications, entertainment and medical applications. These are typically integrated into clothing and dimensions constrained by the dimensions of the body.

(SS3.2)   14:30 A Printed Miniaturised Antenna for UWB Systems ‰

Lu Guo (Queen Mary, University of London, United Kingdom); Sheng Wang (Queen Mary, University of London, United Kingdom); Xiaodong Chen (Queen Mary, University of London, United Kingdom); Clive Parini (QMUL, United Kingdom)

Small and compact UWB antennas have been receiving great interest nowadays due to their applications in Wireless Universal Serial Bus (WUSB), indoor localisation, on-body communications and biomedical implant. Various miniaturisation techniques have been thus exploited to design compact UWB antennas. In this paper, a novel design of printed compact UWB antenna is proposed and studied. A compact size of the antenna has been achieved by combining two miniaturisation techniques, i.e. the quasi-self-complementary structure and the tapered slot. It has been demonstrated that the optimal design of the antenna can offer an ultrawide impedance bandwidth with reasonable radiation patterns. Most importantly, the antenna exhibits both physically and electrically small dimensions, 19mm×16mm in physical size and 0.19λ in electrical size, respectively.

(SS3.3)   14:50 Wideband Conformal Metamaterial Apertures ℅

John L. Volakis (Ohio State University, USA); Justin Kasemodel (The Ohio State University, USA); Chi-Chih Chen (The Ohio State University, USA); Kubilay Sertel (The Ohio State University, USA); Ioannis Tzanidis (The Ohio State University, USA)

This paper introduces a concept of concatenating miniaturized antenna elements to realize wideband arrays. When such arrays are placed conformally, the resulting equivalent circuit (corresponding to each antenna element) is identical to that employed in modeling left-handed transmission lines. Overall, the array emulates propagation within anisotropic media. Such anisotropy introduces added degrees of freedom employed herewith to cancel the reactive loading associated with the ground plane, necessary to achieve wideband performance with a 2:1 VSWR greater than 10:1. A key aspect of the design is the introduction of reactive element along coupled lines forming the antenna element. This presentation will introduce the concept of wideband conformal apertures, their equivalent circuits and specific design demonstrations.

(SS3.4)   15:10 Frequency Notched Wideband Printed Directional Antennas &#

Hong Wei (Southeast University, P.R. China)

Printed wideband and ultra-wideband (UWB) antennas are the simple and low cost electromagnetic radiator design for the front-end system with the low-power and high-data-ratio transmissions. Antenna with stable and directional radiation pattern is critical to maintain the link gain of the wireless communication. With co-existence of UWB and other different wireless systems, UWB antenna with notched band(s) is an effective way to suppress the interference between these systems. This invited talk reviews some of the recent works on these areas, which has been pursued by the author's research group. More information will be presented at the workshop at Lisbon

(SS3.5)   15:30 Ultra-Wideband Dielectric Resonator Antennas &'

Kenny Ryu (University of Mississippi, USA); Ahmed A Kishk (University of Mississippi, USA)

Two novel UWB dielectric resonator antennas (DRA) are designed for broadside radiation and Omni-directional radiation. The dielectric resonator (DR) is mounted on a vertical ground plane edge, which is printed on a thin dielectric substrate. The DR is inserted it in the dielectric substrate by cutting it to fit the dielectric resonator. For the broadside type, the deformation of the radiation patterns in the E-plane that usually occur with these types of antennas has been improved. For the Omni-directional type the cross-polarization level is reduced and the Omni-directionality of the radiation patterns is improved at the upper limit of the UWB. In addition, use of DR improve the radiation efficiency and reduce the antenna size.

PS1: Poster Session 1

(PS1.1) **Analysis and Optimization of MIMO Capacity by using Circuit Simulation and Embedded Element Patterns from Full-Wave Simulation** &+

Kristian Karlsson (SP Technical Research Institue of Sweden, Sweden); Jan Carlsson (SP Technical Research Institute of Sweden, Sweden)

A method for analyzing and optimizing multi-port antennas in MIMO systems is presented and exemplified. The method is based on work presented in [1]-[3] and uses data from full wave electromagnetic field (EM) solvers in combination with circuit simulations for efficient calculations of radiation properties of multi-port antennas. Here it is shown that the method can also be used for simulations of antennas in a MIMO system. The main advantage of the proposed method is that only a few full-wave simulations, which usually are time consuming, are needed when e.g. optimizing the matching circuits for a multi-port antenna. Since embedded element patterns are used, MIMO capacity (and of course all other relevant antenna parameters) can efficiently be computed for any matching network connected to the antenna ports and for different channel models, both statistical and deterministic.

(PS1.2) **Dual Band Printed Square Quadrifilar Helix Antenna for Global Navigation Satellite Systems** ' %

Steven Gao (University of Surrey, United Kingdom)

In this paper, a novel dual-band printed square quadrifilar helix antenna (QHA) is presented. The antenna can cover the L1 and L2 bands (centered at 1.575 GHz and 1.227 GHz, respectively) of Global Navigation Satellite Systems (GNSS). It achieved good impedance matching and circularly polarized radiation patterns within both L1 and L2 bands. The antenna (without the feed network) has very small size of 1cm $\times$ 1cm $\times$ 1cm only, and is very light weight. The feed network for the antenna is also designed. To prove the concept, a prototype is developed. Both measured and simulated results are presented and discussed. The antenna is useful for GNSS receivers onboard small satellites, air planes and mobile vehicles on the ground.

(PS1.3) **A New Broadband Trapezoidal Flat Monopole Antenna** ')

Behrouz Heydari (Asian Ellite Co., Iran); Moosa Sharbati (Asian Ellite Co., Iran)

The necessity to use a great bandwidth in communication industries led to a change of the shape of the monopole antennas and use of a flat rather than a bar as radiator. This type of antenna was proposed for the first time in 1958 by Mr. B.J. Lamberty in the form of a rectangular plate. From then on, other similar antennas were presented in the shape of circular, elliptical, and trapezoidal discs which meant to increase the bandwidth. That, in turn, led to a better radiation pattern which ended in the improvement of the designs. Having this in mind, we leave tried in this article to present a new shape of broadband monopole antennas with proper bandwidth and radiation pattern as following.

(PS1.4)   Effects of Ground Plane Size on a Square Microstrip Patch Antenna Designed on a Low-Permittivity Substrate with an Air Gap（#

Minh Tuan Nguyen (Ajou University, Korea); Byoungchul Kim (Ajou University, Korea); Hosung Choo (Hongik University, Korea); Ikmo Park (Ajou University, Korea)

The effects of ground plane size on the characteristics of a square microstrip patch antenna designed on a low-permittivity substrate with an air gap were investigated. The characteristics studied include return loss, gain, half-power beamwidth (HPBW), and radiation pattern. The gain and HPBW varied periodically with increasing ground plane size, and were out of phase with each other. The relationship of the above parameters with the height of the antenna was also considered. Decreasing the antenna height changed the smallest ground plane size for impedance matching, and also reduced back radiation, which improved the front-to-back level of the microstrip patch antenna.

(PS1.5)   A Simple Planar High-Directivity Yagi-Uda Antenna with a Concave Parabolic Reflector（'

Huan-Chu Huang (National Taiwan University, Taipei, Taiwan, Taiwan); Jen-Chen Lu (HTC Corporation, Taoyuan, Taiwan, Taiwan); Powen Hsu (National Taiwan University, Taiwan)

A simple planar Yagi-Uda antenna with a single director and a concave parabolic reflector on a thin dielectric substrate is proposed. Through the innovative design, the simple Yagi-Uda antenna can achieve the high directivity of 9.0 dBi, front-to-back ratio of 14.5 dB, cross-polarization level of −38.7 dB, bandwidth of 6.0%, and the radiation efficiency of 85.1%, i.e., better than −1 dBi in terms of the 3D average gain. This proposed antenna is especially suitable for the mobile devices with GPS functions. In addition, this proposed antenna can also benefit the design of the highly directive arrays.

(PS1.6)   Wideband Slotted Patch Antenna using EBG Structure（+

Utsav Chandra (Brunel University, United Kingdom); Hattan F. AbuTarboush (Brunel University, West London, United Kingdom); Hamed Al-Raweshidy (University of Brunel, United Kingdom); Rajagopal Nilavalan (Brunel University, United Kingdom)

A slotted small microstrip patch antenna is designed with Electromagnetic Band gap (EBG) structures. The performance parameters of the presented antenna are then compared with the conventional patch antenna. It is realized that there is a significant increase of bandwidth and better suppression of harmonics than the normal patch antenna. This antenna is thus operating in the frequency band 5 -6 GHz which is one of the most usable bandwidth regions for wireless applications such as WiMAX, WiFi outdoor, WLAN, Hiperlan/2 and many more. The proposed antenna achieves a gain between 4 to 6 dBi built in FR-4 material.

(PS1.7) Compact Dual-Band (2.4/5.2GHz) Monopole Antenna for WLAN Applications 〉%

Amit Rathore (Brunel University, United Kingdom); Rajagopal Nilavalan (Brunel University, United Kingdom); Hattan F. AbuTarboush (Brunel University, West London, United Kingdom); Thomas Peter (Brunel University, United Kingdom)

A compact and optimized design of a rectangular printed monopole antenna with slits and truncated ground plane on FR-4 substrate is presented. The proposed antenna is designed for dual-band operation at 2.4GHz and 5.2 GHz for Wireless Local Area Network (WLAN) applications with S11< -10 dB and VSWR < 2.0. The antenna has good return loss and radiation characteristics in required frequency band. The proposed antenna gives omnidirectional radiation pattern in the E Plane and H plane over the frequency range of 2.4GHz and 5.2GHz. The calculated and measured results in terms of return loss show good agreement and the results also show good wideband characteristics.

(PS1.8) Feed Point Optimization of a Microstrip Sierpinski Carpet Antenna 〉〉

Raza Hussain (COMSATS Institute of Information Technology, Islamabad, Pakistan, Pakistan)

In order to achieve multibands, sierpinski carpet geometry is employed on microstrip patch antennas. A sierpinski carpet is a kind of fractal in which a square in a plane is subdivided into nine congruent squares, with the open central one dropped. Since the central area is not filled with a radiating material, therefore the position of transmission line will have a great effect on the performance of the antenna. In this paper we will examine the effects of position of transmission line, and find an optimum feed point for a microstrip sierpinski carpet antenna. The designed antenna can be used for WLAN, Buetooth and WiMAX.

(PS1.9) Novel Electrically Small Spherical Electric Dipole Antenna *#

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

This paper introduces a novel electrically small spherical meander antenna. Horizontal sections of the meander are composed of wire loops, the radii of which are chosen so that the whole structure is conformal to a sphere of radius a. To form the meander the loops are connected by wires at a meridian plane. The antenna operates as an electric dipole, i.e. it radiates the TM10 spherical mode. The antenna is self-resonant and can be matched to a wide range of input feed lines without an external matching network. In this paper, a spherical meander antenna of the size ka=0.27 and the input impedance of 72 ohms is numerically investigated and its performance is compared to that of the multiarm spherical helix antenna of the same size. Both antennas yield equal quality factors, which are about 1.5 times the Chu lower bound, but quite different cross-polarization characteristics.

(PS1.10) Design Investigation of Circularly Polarized Dielectric Resonator Antenna Excited by Dielectric Image Line *'

Emran Mousavi Kejani (Ferdowsi University of Mashhad Iran, Iran); Mohmmad Neshati (Ferdowsi University of Mashhad, Iran)

In this paper a circularly polarized (CP) Dielectric Resonator Antenna (DRA) is numerically investigated using a commercial software package based on Finite Element Method (FEM). An Elliptical resonator is positioned on a metallic plate excited through a narrow slot located at the centre of the ground. A Dielectric Image Line (DIL) placed at the back side of the plane is used to excite the slot and the DRA. The DIL is connected to three section transitions of standard WR90 waveguide to reduce return loss of the structure. The antenna parameters including return loss, radiation patterns, gain variation versus frequency are presented. Results show that 4.5% bandwidth is obtained for 3-dB Axial Ratio (AR) at 10 GHz.

(PS1.11) An Intermediate-Field Approach of the Differential Time-Domain Single-Antenna Method for Electrically Large Ultra-Wide Band Antennas *+

Razvan Tamas (Constanta Maritime University, Romania); Laurence Babour (Institute of Microelectronics, Electromagnetism, and Photonics, France); Alin Danisor (Ovidius University of Constanta, Romania); George Caruntu (Constanta Maritime University, Romania)

The single-antenna method consists of a virtual transmission between the antenna under test and its image in a conducting reflector. In a previous work we proposed a differential, time-domain single-antenna approach that was found suitable for measuring the impulse response of an ultra-wide band antenna. The approach provides accurate results within the far-field distance range. However, when measuring large ultra-wide band (UWB) antennas operating in the lower UWB frequency band for military applications, i.e., from 0.1 to 1 GHz the distance between the antenna and its image usually falls close to the lower limit of the Fraunhofer region. This paper presents an intermediate-field approach of the time-domain differential single antenna method, based on defining a normalized received signal that can be averaged over a set of distances. The proposed technique is established theoretically and validated experimentally on a cylindrical UWB monopole antenna.

(PS1.12) A novel slot-coupling feeding technique for circularly polarized patch antennas +%

Alice Buffi (University of Pisa, Italy); Roberto Caso (University of Pisa, Italy); Marcos Pino (Universidad de Oviedo, Spain); Paolo Nepa (University of Pisa, Italy); Giuliano Manara (University of Pisa, Italy)

In this paper a novel slot-coupling feeding technique is used to feed a circularly polarized patch antenna. The antenna is fed through two microstrip lines which are excited 90° out-of-phase and coupled to a square patch by means of a square ring slot realized in the feeding network ground plane. Design procedure and simulation results are shown for a 2x2 array working in the WiMax 3.3-3.8 GHz frequency band. Due to both the symmetry properties of the novel slot-coupling feeding technique and the implementation of a sequential rotation technique, excellent axial ratio performance is achieved in a wide frequency band where return loss is greater than 10dB and axial ratio is less than 3dB for any direction in the antenna main beam.

(PS1.13) Electrically Small Receive-Only Resonant Antennas with Wideband Performance for FM Radio Reception in Mobile Phones +)

Peter Lindberg (Laird Technologies AB, Sweden); Stefan Irmscher (Laird Technologies AB, Sweden); Andrei Kaikkonen (Laird Technologies AB, Sweden)

An antenna concept for FM radio reception in mobile phones is proposed and evaluated. By resonating a loop or monopole radiator with a shunt element and connecting the antenna to a high-impedance low noise amplifier, an equivalent antenna efficiency of -24±3 dB is achieved over the entire band of 88 – 108 MHz despite having high-Q gain characteristics and without using control voltages for frequency tuning. Due to the resonant frequency behavior >45 dB isolation against co-located transmitting antennas is realized, thereby preventing the amplifier from being saturated during simultaneous operation. A comparison with the hands-free cord and other possible internal solutions is included.

(PS1.14) Segmented Circular Strip Planar Leaky-Wave Antenna Designs for Broadside Radiation and One-Sided Beam Scanning #" #

Symon K Podilchak (Queen's University, Canada); Al P. Freundorfer (Queen's University, Canada); Yahia Antar (Royal Military College of Canada, Canada)

Planar antenna designs that utilize surface waves (SWs) for leaky wave (LW) excitation are investtigated for millimeter wave frequencies of operation. Surface-wave launchers (SWLs) are employed as the antenna source generating cylindrical SWs for bound propagation on a grounded dielectric slab (GDS). By the addition of a segmented circular strip grating configuration, a partially reflecting surface (PRS) can be realized, providing suitable conditions for 2-D leaky-wave radiation. Measurements illustrate broadside beam patterns are possible in both the E and H planes with a 10deg half power beamwidth. More specifically, a directive pencil beam is observed just at the edge of the TE1 SW mode cuttoff frequency of the slab, suggesting maximum radiation at the edge of a TE stopband. Directive pencil beam patterns at broadside, with gain values greater than 12 dBi at 19.5 GHz, can be achieved.

(PS1.15) Handheld Dielectric Resonator Antenna for Ultra Wideband Applications #"'

Laure Huitema (Xlim-UMR 6172, France); Majed Koubeissi (University of Limoges, France); Cyril Decroze (XLIM, France); Thierry Monediere (University of Limoges, France)

A novel design of compact dielectric resonator antenna (DRA) dedicated to ultra wideband applications such as Digital Video Broadcasting-Handheld (DVB-H) is presented in this paper. A miniaturization technique has been performed in order to reduce the antenna size. The obtained dimensions of the final design of the DRA are λ0/7 x λ0/13 x λ0/28 at 466MHz. Also, measurements are presented to validate the results obtained via simulation. The proposed antenna offers a bandwidth of 70% around 700MHz for –8dB impedance bandwidth definition and covers the Ultra High Frequency (UHF) IV, V and Global System for Mobile communications (GSM) bands. Finally a DRA using magneto-dielectric materials is presented and its performances are shown.

(PS1.16) Printed Fractal Monopole Antenna Array for WLAN #" +

Qi Luo (INESC Porto, Portugal); Jose Pereira (IT Aveiro/ University of Aveiro, Portugal); Henrique M. Salgado (University of Porto, Portugal)

This paper presents the design of a single feed multiband printed monopole antenna array using the 2nd generation of the Minkowski fractal geometry. During this work, it is found that adding a rectangular stub on the ground plane, the impedance match of the antenna can be improved with little influence on the original resonant frequencies. Meanwhile, the antenna array on a PDA size substrate was also designed and fabricated. The experimental results show that it can operate from 2.32 to 2.49 and from 5.1 to 5.88 GHz, which covers the required bands for IEEE 802.11a/b/g (2.41-2.48 GHz, 5.15-5.35 GHz and 5.725-5.875 GHz) applications. Measurements indicate that the maximum gain of this printed monopole array can reach 2.3 dBi at lower band and 5.6 dBi at upper band.

(PS1.17) A Time Domain Study of A Small Quasi-Self-Complementary UWB Antenna ##%

Lu Guo (Queen Mary, University of London, United Kingdom); Sheng Wang (Queen Mary, University of London, United Kingdom); Xiaodong Chen (Queen Mary, University of London, United Kingdom); Clive Parini (QMUL, United Kingdom)

A time domain study of a small quasi-self-complementary UWB antenna is presented in this paper. A brief description of antenna geometry and its frequency domain performance are illustrated first. It has been demonstrated that the antenna can yield an ultrawide impedance bandwidth with a rather small dimension, 16mm*25mm in physical size and 0.24 λ in electrical size, respectively. A comprehensive time domain investigation of the antenna is then conducted. To explore more in detail the time domain behaviours of the antenna, various measurements for different antenna pair orientations are carried out. It has been shown that the small quasi-self-complementary UWB antenna generally demonstrates a good performance in both the frequency and the time domain.

(PS1.18) Design of a M-EBG Sectoral Antenna array achieving wide angle beam scanning ##)

Mohamad Hajj (University of Limoges, France); Dina Serhal (University of Limoges, XLIM laboratory, France); Hassan Chreim (University of Limoges, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Bernard Jecko (University of Limoges, France)

In this paper, we introduce a new technique of electronic beam scanning which can be carried out by using a joint array of M-EBG sectoral antennas. This study opens new avenues of research on M-EBG sectoral antennas by combining multiple radiant elements into an array; these antennas have the advantage of the opportunity to achieve agile structures. The proposed technique can also be used to solve problems of constrained beam scanning by reducing mutual coupling between elements. Beam scanning angles of 58 degrees in the horizontal plane were obtained for an array antenna pattern. The proposed structure presents more than 24 dB directivity enhancement as compared to those of a radiant element with 15 dB directivity. The principle is explained and applied to a Hiperlan2 ([5.47-5.725] GHz) antenna.

(PS1.19) The Cantor Dielectric Fractal Multilayer as an Omnidirectional Mirror #$#

Francesco Chiadini (University of Salerno, Italy); Antonio Scaglione (University of Salerno, Italy); Vincenzo Fiumara (University of Basilicata, Italy); Ilaria Gallina (University of Sannio, Italy)

Analysis of the reflecting features of Cantor dielectric multilayers for oblique incidence shows that, for suitable values of the refractive indexes of the two constituent materials, they behave as an omni-directional mirror. The Cantor multilayer still keeps the characteristics of omnidirectional mirror also for lossy materials. The main effect of the material dissipation is to increase the minimum value of the dips delimiting the reflecting band and, consequently, to broaden the rejected frequency band. Comparison with a periodic quarter-wave stack having the same constituent materials points out that the Cantor multilayer has an higher rejection level with a narrower bandgap.

(PS1.20) A Large Number of Phased Array Antenna with Low Grating Lobes Using Partially Driven Technique #$'

Tamotsu Suda (Japan Radio Co., Ltd., Japan); Yasuhiro Kazama (Japan Aerospace Exploration Agency, Japan); Hasegawa Shohei (Aoyamagakuin University, Japan); Osamu Hashimoto (Aoyama Gakuin University, Japan); Tadashi Takano (Japan Radio Co., Ltd., Japan)

Abstract— In this paper, a phased array antenna which has a large number of element antenna and low grating lobes is described. The element antenna has a conical shaped radiation pattern which is suitable for a mobile satellite communications. To reduce a number of phase shifter, partially driven array technique which is one kind of thinned array is employed. The beam scanning characteristics of 243-element array antenna are investigated computationally. To reduce grating lobe level, a diamond shaped sub-array is proposed. The sub-array consists of 16-element and is formed by triangle arrangement. Owing to this proposed arrangement, the level of grating lobe is achieved almost 15dB below the peak gain of the array antenna.

(PS1.21) Novel Structural Design for Compact and Broadband Patch Antenna #$+

M Pramod Kumar (Sreenidhi Vaughn College of engineering, India); VSK Reddy (Sreenidhi Vaughn College of engineering, India)

Microstrip antennas inherently have a narrow bandwidth, and bandwidth enhancement is usually demanded for practical applications. Thus, the present paper discusses about the novel design for compact and broadband microstrip antennas. The bandwidth of the designed antenna is enhanced by reactively loading with slots symmetrically to one of the axis. The antenna was designed for operating in S band frequency range with a linear polarization. The feeding arrangement exhibited in the designed model is coaxial connector in the ground plane with the center-pin extended to the patch as an inductive probe although other feeding methods could be easily adapted. The designed antenna successfully attains a bandwidth of 24.5% at 10dB return loss with the central frequency of 2.1 GHz; also the antenna attains a gain of 9.1dB at its resonant frequency. The simulated 3dB beamwidth is of about 110 and 98.2 in E-plane and H-plane respectively.

(PS1.22) A Single Feed Multi-Band Internal Antenna for Mobile Communication Terminals #%&%

Jian Liu (Xi'an University of Science and Technology, P.R. China)

In this paper, we describe a single feed multiple-bands internal antenna that is designed for mobile and wireless application. A planar inverted-F antenna (PIFA) is configured as the basic architecture, the multi-band are achieved by integrating a U-shape strip line and an inverted L radiator. The PIFA antenna produces the first resonant frequency at 2GHz band; the U-shaped strip line produces the second resonant frequency at 2.4GHz band; the inverted L radiator the third resonant frequency at 5.8GHz band. The designed antenna is band wide enough to support mobile and wireless scenarios of UMTS (3G) band from 1920MHz to 2170MHz; Bluetooth WLAN at 2.4GHz; WALN at 5.8GHz. The antenna was designed by MWS CST software that was validated by experimental measurement.

(PS1.23) Waveguide to Microstrip Transition at 235 GHz #%)

Michael Jenning (Dresden University of Technology, Germany); Martin Kurras (Dresden University of Technology, Germany); Dirk Plettemeier (Dresden University of Technology, Germany)

In his paper a transition from a WR-3 rectangular waveguide to an 85 μm wide microstrip line is designed and manufactured. The transition is a low-cost transition fabricated in a standard lithography process on 5mil thick Rogers RO3003 material. Furthermore the transition can be easily attached to the waveguide without modifying or damaging the waveguide itself. Full S-parameter measurements were done and the obtained results will be given. Additionally problems, especially those caused by fabrication tolerances, with respect to the wavelength, will be discussed and the observed deviation of the measurement results from the optimum simulation results is analyzed.

(PS1.24) Relative Clearance of Small Antenna #&#

Hiroyuki Arai (Yokohama National University, Japan)

This paper shows relative antenna clearance to discuss electrically occupied space of small antenna element by defining the input impedance variation in the presence of electrical disturbance near tested antennas. A half wavelength conducting wire is introduced as the disturbance. The introduction of relative clearance provided quantitative analysis of the electrical volume for different shaped antennas. The half wave dipole antenna requires a quarter wavelength opening space to have a stable resonance. The clearance is decreased by the antenna miniaturization such as meander shape by 20 %, and is reduced by the folded geometry by 40 %. The distributed current near the feed point also reduce the clearance such as stub matching geometry. The physical miniaturization is provided by the antenna geometry design, however, the electrically occupied space should be considered to obtain physically and electrically small antennas using the concept of antenna relative clearance.

(PS1.25) Dual Polarization X-Microstrip Array Antenna #&'

Mohd Syaiful Redzwan Mohd Shah (Universiti Teknikal Malaysia Melaka, Malaysia)
This paper briefly present a design of array antenna with inset-fed microstrip patch antenna oriented at 45º and -45º. The antennas are capable to generate dual-polarization radiation pattern oriented at desired direction. The designs were simulated in CST Studio Suite. This antennas were fabricated on FR4 substrate with a dielectric constant εr =4.7, tan δ =0.019 and thickness =1.6mm. The simulation and measurement results have been compared. For the measurement setup of radiation pattern, the reference of transmitter is using monopole antenna The designs of X-microstrip array antennas yield a bandwidth of 105 MHz or 4.24% and antenna gain is 7.89 dBi.

(PS1.26) New Size Reduction for Patch Antenna by Parasitic Shorting Elements #&+

Hang Wong (City University of Hong Kong, Hong Kong)
This paper presents a new size reduction technique for a microstrip antenna by adding parasitic L-shaped shorting strips which are equivalent to provide capacitive and inductive loading effects to the patch. With the use of these parasitic elements, the antenna finds an obvious size reduction while maintaining a good broadside radiation characteristic. Because of this attractive radiation feature, the antenna is suitable for circularly polarized (CP) antennas. A new small CP patch antenna operating at 2.492GHz is therefore proposed using a microwave substrate of dielectric constant, εer=10, with a coaxial probe feed. The total area of reduction is about 82% in comparison with the conventional half-wave patch antenna.

(PS1.27) An Elliptical UWB Monopole Antenna with Reduced Ground Plane Effects #' %

Yang Lu (University of Liverpool, United Kingdom); Yi Huang (University of Liverpool, United Kingdom); Hassan Chattha (University of Liverpool, United Kingdom); Yao-Chun Shen (University of Liverpool, United Kingdom); S. J. Boyes (University of Liverpool, United Kingdom);
Ultra-wideband (UWB) is now commonly known as a new technology for short-range and high-speed wireless communications, which has attracted a lot of research to develop UWB antennas for emerging applications. Among all the UWB antennas developed in the past few years, the planar monopole antennas have attracted the most. In this paper, a new approach on how to reduce the ground plane effects for a compact microstrip feed elliptical UWB monopole antenna is proposed. The L shape cuts on the edge of the ground plane are introduced to reduce the ground plane effects. It is shown that this method changes the current distribution on the ground without sacrificing the time domain performance thus making the antenna suitable for different ground sizes.

(PS1.28) A Printed LPDA with UWB Capability #')

Giovanni Andrea Casula (Università di Cagliari, Italy); Giuseppe Mazzarella (University of Cagliari, Italy)
This work deals with the design of a wideband microstrip log periodic array operating between 4 and 18 GHz (thus working in C,X and Ku bands). A few studies, since now, have been proposed but they are significantly less performing and usually quite complicated. Our solution is remarkably simple and shows both SWR and gain better than likely structures proposed in the literature. The same antenna can also be used as an UWB antenna. The design has been developed using CST MICROWAVE STUDIO 2009, a general purpose and specialist tool for the 3D electromagnetic simulation of microwave high frequency components.

(PS1.29) Influence of the Substrate Anisotropy in the Planar Antenna Simulations #(#

Plamen Dankov (University of Sofia, Faculty of Physics, Bulgaria, Bulgaria)

The influence of the dielectric anisotropy of the materials in the planar antenna design is considered in this paper. The measurement of the parallel and normal dielectric parameters of the samples (dielectric constant and dielectric loss tangent) is described and measured parameters of some known substrates are presented. The possibility to take into account of the material anisotropy into the modern simulators and the concept of the equivalent substrate parameters is discussed. Finally, the influence of the dielectric anisotropy over the parameters of some antenna elements is investigated: antenna feed lines, matching of the planar radiators and the multi-layer antenna radomes.

(PS1.30) Experimental Characterization of a Reconfigurable Multiband Minkowski Patch Antenna #('

José Trindade (Federal University of Rio Grande do Norte, Brazil); Paulo Silva (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, Brazil); Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil)

In this work a reconfigurable Minkowski patch antenna has been designed, fabricated, and measured. The proposed patch antenna has the advantage of low profile, lightweight, and easy fabrication, and is potential for wireless communication applications. Ansoft DesignerTM software aided the regonfigurable multiband antenna design with applications for wireless networks. In particular, a prototype was built with applications for Wi-Fi considering for the IEEE 802.11 a standard and WiMAX. Frequency reconfigurability is achieved by means of switches placed on the pre-fractal edges of the proposed antenna. The conducted experimental characterization of the Minkowski patch antenna was done with a vector network analyzer in the range of 100 KHz to 7.0 GHz and showed very promising results.

(PS1.31) Design of an Ultra Wideband Universal Serial Bus Device Mounted Antenna #(+

Nuno Pires (Instituto Superior Técnico, Portugal); Marco Letizia (École Polytechnique Fédérale de Lausanne, Switzerland); Achim Maisenbacher (ads-tec GmbH, Germany)

The present paper reports on the simulation, construction and measurement of a planar Ultra Wideband (UWB) monopole antenna designed to operate inside a Universal Serial Bus (USB) dongle, aiming at usage in industrial applications. Inexpensive FR4 substrate with 4.4 relative electrical permittivity and 0.8 mm thickness was used and the antenna shape and dimensions fit in a common case. The built antenna prototype was tested inside a USB device case in free space and in a realistic antenna deployment scenario, with the dongle connected to a laptop computer. It was found that the designed antenna exhibits acceptable |S11| matching in the frequency range [2.5; 12] GHz, allowing its usage in UWB and other wireless services such as Bluetooth, LTE and IEEE 802.11.

(PS1.32) The Optimal Design of Patch Antennas with Smooth Border #) %

Bangda Zhou (Shanghai Jiao Tong University, P.R. China); Junping Geng (Shanghai Jiaotong University, P.R. China); Rong Hong Jin (Shanghai Jaio Tong University, P.R. China); Xianling Liang (Shanghai Jiaotong University, P.R. China); Sheng Ye (Shanghai Jiao Tong University, P.R. China)

A novel method to design patch antenna with computer-aid is presented in this paper. Smooth curve is used to generate the border of the patch antenna; and particle swarm optimization (PSO) algorithm is implemented to control the shape of the patch, which leads the result less dependent on designer's experience and more reasonable. Finite Difference Time Domain (FDTD) algorithm is used for electromagnetic simulation. The optimization of process is conducted on the parallel cluster to reduce computational time. To verify the correctness of this method, an antenna working on WLAN band has been optimized and fabricated. The experiment result is showed in the end.

(PS1.33) Backscattering Improvement of UHF RFID Tag Efficiency #))

John Sahalos (Aristotle University of Thessaloniki, GR-54124, Thessaloniki, Greece, Greece); Aggelos Bletsas (Technical University of Crete, Greece); Antonis G Dimitriou (Aristotle University of Thessaloniki, Greece)

In this work, a tag-load selection methodology is proposed for optimized tag-to-reader backscatter communication. Derivation of the method is based on antenna/communication theory and applies to any tag-antenna, including minimum scattering antennas as a special case. In contrast to what is commonly believed, it is shown that amplitude maximization of complex reflection coefficient difference between the two states is not a sufficient condition for optimized tag's design. Maximization of backscatter carrier power per bit must be sought as well. Optimum load-selection for passive and semi-passive tags is linked to the tag-antenna's structural mode. A method that allows for the closed-form calculation of this parameter is put forward.

(PS1.34) Dual Band Planar Folded Monopole #*

Morana Banozic (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia); Juraj Bartolic (University of Zagreb, Croatia); Branimir Ivsic (University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia); Tomislav Debogovic (University of Zagreb, Croatia)

In this paper an improved design of a dual band planar folded monopole is proposed. A folded monopole antenna is constructed by truncating the folded dipole antenna by half and attaching the ground plane. The planar folded monopole has been analyzed theoretically and experimentally. The design was extended to a dual band operation. The proposed monopole is successfully simulated, designed, and measured, showing stable radiation patterns and good matching properties in both frequency bands. Two monopoles are designed, for 2 and 3 GHz bands, and for 2 and 3.5 GHz bands. The proposed antennas have potential applications in the ceiling mount base stations for indoor communications and wireless positioning including adaptive MIMO systems for mobile terminals.

SS4:   Small Antennas and Sensors

Chairs: Zhi Ning Chen (Institute for Infocomm Research, Singapore); Steven Best (The MITRE Corporation, USA)

(SS4.1)   8:30 Antennas for RFID Applications (Keynote) #*'

Zhi Ning Chen (Institute for Infocomm Research, Singapore); Xianming Qing (Institute for Infocomm Research, Singapore, Singapore)

Antenna is one of the key factors in radio frequency identification (RFID) systems. The performance of the reader / tag antennas shows significant effect on the reading range and detection accuracy of an RFID system. Optimized antenna design will benefit the RFID system with longer reading range, better accuracy, reduced antenna fabrication cost, and simple system configuration and implementation. Since RFID systems operate at frequencies varying from low frequency (LF) to microwave frequencies (MWF), the RFID antenna designs are with distinct requirements. In this paper, we address the antenna design considerations for the latest RFID applications. Several antennas are exemplified to show the recently developed technologies for RFID antenna designs in specific RFID applications.

(SS4.2)   9:00 UHF Near-Field RFID Antennas #* +

Xianming Qing (Institute for Infocomm Research, Singapore, Singapore); Zhi Ning Chen (Institute for Infocomm Research, Singapore)

Near-field radio frequency identification (RFID) technology has been traditionally used at low frequency (LF) and high frequency (HF) bands; now developing this technology at ultra high frequency (UHF) band is of increasingly interest. Designing a UHF near-field RFID reader antenna is one of the most challenging tasks. Traditional loop antennas cannot operate properly at the UHF band when the antennas tend electrically large so that they are unable to generate strong and uniform magnetic field in an adequate interrogation zone. A number of techniques have been presented to design UHF near-field RFID reader antennas, which enables the electrically large loop-type antenna generating desired magnetic field distribution. In this paper, the challenges of the UHF near-field antenna design are addressed. The state-of-art UHF near-field antenna techniques are reviewed and discussed.

(SS4.3)   9:20 Single Wideband Card Antenna for LAN and UWB Systems #+%

Hisamatsu Nakano (Hosei University, Japan); Tatsuya Igarashi (Hosei University, Japan); Yasushi Iitsuka (Hosei University, Japan); Junji Yamauchi (Hosei University, Japan)

The design procedure for a card antenna that operates at frequencies for LAN and UWB systems, designated as the PaSP, is described in four steps (four antennas, Ant-1 through Ant-4). The investtigation for Ant-1 reveals that the VSWR below 6 GHz needs to be reduced. Ant-2, consisting of a main patch and a short-circuited patch, reduces the lower edge frequency of the operating band to approximately 4 GHz. Further decrease in the lower edge frequency is achieved in Ant-3, where the height of the short-circuited patch is increased. As a result, a lower edge frequency of approximately 3 GHz is obtained. The final antenna, Ant-4, whose short-circuited patch has a horizontal strip added to it, realizes a lower edge frequency of less than 2.4 GHz. Note that Ant-4 is the antenna we have designated as the PaSP, where the top element size is small.

(SS4.4)   9:40 Progress Towards the Design of an Electrically Small Huygens Source #+)

Steven Best (The MITRE Corporation, USA)

In this paper, we describe our progress to date in the design and realization of an electrically small Huygens source. We begin discussing work by Yaghjian that predicts the maximum directivity achievable with single and dual Huygens sources. Here, we attempt to realize the Huygens source utilizing electrically small electric and magnetic dipoles. Using straight-wire dipole and circular-loop elements, we demonstrate that the directivities predicted by Yaghjian can be achieved with the single and dual Huygens sources. Next, we attempt to realize the Huygens source using recently described, more practical electrically small electric and magnetic dipoles. In free space, these antennas are impedance matched to 50 Ohms and exhibit a quality factor (Q) that approaches the lower bound (the Chu limit). When used in the realization of a Huygens source, these antennas no longer exhibit neither matched impedances nor low Q's. The limitations that arise in realizing the Huygens source are discussed.

(SS4.5)   10:00 Multi-band Linear and Circular Polarized, Electrically Small, Near Field Resonant Parasitic Antennas $" #

Peng Jin (University of Arizona, USA); Chia-Ching Lin (University of Arizona, USA); Richard W. Ziolkowski (University of Arizona, USA)

We have developed a variety of electrically small, near-field resonant parasitic (NFRP) antennas. Several examples and their performance characteristics will be presented. These are based on capacitively-loaded loop (CLL) NRFPs with both electric and magnetic couplings to the driven element; both varieties will be compared and contrasted. Integrating multiple NFRP CLL elements with coaxially-fed electrically-small monopoles or semi-circular loop antennas, both single - and dual-band, linearly (LP) and circularly polarized (CP) antenna designs are achieved. The CP designs rely on two orthogonal equivalent magnetic dipoles tuned at slightly different resonance frequencies to achieve the requisite 90° phase shift between them at an intermediate frequency. Two driven monopoles are required for the electrically-coupled version; one driven semi-loop antenna is required for the magnetically-coupled version. However, only the electrically-coupled design has enough tuning parameters to lead to a dual-band, NFRP CLL-based CP antenna. This dual-band CP design will be discussed in our presentation.

(SS4.6)   10:20 Research on Broadband Circular Polarized Microstrip Patch Antenna $" '

Wenju Huang (Tsinghua University, P.R. China); Zhenghe Feng (Tsinghua University, P.R. China)

This paper studies the method to broaden the circular polarized bandwidth of microchip patch antennas in different forms. For single patch, the simulation result shows that: as the dielectric thickness increases, CPBW also will be increased in accordance with the law of linear approximately; the impact of changing the dielectric constant to CPBW is not large. The impedance bandwidth and CPBW of the patch respectively reach 12.9% and 3.45%. To broaden the bandwidth, another two antennas are designed. One is 2×4 antenna array; the other is double-layer patch antenna. From the results simulated and tested, we can see that the CPBW of these two type antennas have reached 10.3% and 10.86% respectively, which shows that, these two methods to broaden CPBW of microchip patch antenna are very effective.

SS5: Antenna Measurements and Validation

Chairs: Yi Huang (University of Liverpool, United Kingdom), Lars Jacob Foged (SATIMO, Italy)

(SS5.1) **11:00 OTA Measurements of Wireless Stations in Reverberation Chamber Versus Anechoic (Keynote) $" +**

Per-Simon Kildal (Chalmers University of Technology, Sweden)

The paper explains the fundamental differences between the propagation environments emulated by the anechoic chamber (AC) and the reverberation chamber (RC). The AC emulates free space, representative for antennas mounted on rooftops or masts with Line-Of-Sight (LOS), whereas the RC emulates a rich isotropic multipath environment with Rayleigh fading, representative for mobile wireless stations in urban and indoor environments with Non-Line-Of-Sight (NLOS). The paper will go through the fundamental differences of these two types of measurement chambers, in order to conclude that the RCs means the same to antennas in multipath environments as the ACs do to antennas in free-space-like environments. They enable an objective and repeatable antenna characterization. Thereby, the RC and AC complement each other. They are both needed.

(SS5.2) **11:30 Wideband Antenna Efficiency Measurements $#(**

Yi Huang (University of Liverpool, United Kingdom); Yang Lu (University of Liverpool, United Kingdom); Hassan Chattha (University of Liverpool, United Kingdom); N. Khiabani (University of Liverpool, United Kingdom);

In this paper, we examine the antenna efficiency measurement techniques which have been used up to now, and identify their advantages and disadvantages for broadband antenna measure-ments. It is shown that the classic Wheeler cap method, which is the best for electrically small antennas, has a lot of attractive features even for broadband antenna measurements in terms of the cost and efficiency while the newly proposed reverberation chamber method may become a good alternative method. A "source stirred" method is proposed as a new approach for the broadband antenna efficiency measurement and its major advantages are cheap, convenient, and efficient. Both the experimental and numerical results are provided. It is shown that the loss due to the imperfection of the cavity can cause a serious problem for obtaining an accurate result.

(SS5.3) 11:50 Applications of the Diagnosis Techniques in Antenna for the Reduction of the Measurements Errors $$"

Manuel Sierra-Castaner (Universidad Politécnica de Madrid, Spain); Francisco José Cano (Polytechnic University of Madrid, Spain); Sara Burgos (Universidad Politécnica 1449Bde Madrid (Technical University of Madrid), Spain); Jose Luis Besada (Universidad Politécnica de Madrid (Technical University of Madrid), Spain)

This paper shows several applications of the diagnostic techniques for the reduction of some error or uncertainty factors in antenna measurements. The method is based in the calculation of the extremely near field from the far field using FFT (Fast Fourier Transform) Techniques, improved with the Gerchberg-Papoulis Algorithm. The classical applications of the diagnostic techniques are errors detection, like phase errors in arrays or conformal errors in reflectors. Therefore, they constitute an important antenna design tool. Also, they can be used for other applications whose aim is improve the measurements in anechoic chambers. This paper shows different process applied to reduce the effect of the reflections, the effect of the leakage from AUT (Antenna under test), to improve the signal to noise and to reduce the truncation error in the planar or cylindrical near field.

(SS5.4) 12:10 Electronically Scanned Arrays for Fast Testing of Large Antennas $$&

Lars Jacob Foged (SATIMO, Italy); Luc Duchesne (SATIMO, France); Ludovic Durand (SATIMO, France)

The use of probe array is a well established technology for spherical near field systems offering all the possibilities and accuracies of traditional single probe testing at a much faster speed. Recently the problem of exhaustive testing of the high number of multi beam antennas embarked on future satellite systems has received considerable attention. Based on conventional measurements techniques this testing would lead to unacceptable cost and duration. Solutions based on "hybrid systems" taking full advantage of fast probe array technology on large mechanical scanners can drastically reduce the measurement time compared to conventional single probe test systems. This paper discuss the adaptation of a fast multi probe technology to an existing classical planar near field facility through the manufacturing, installation and test of a partial demonstrator in Thales Alenia in Toulouse

SS6:   Millimeter, Sub-Millimeter and THz Antennas

Chairs: Peter de Maagt (European Space Agency, The Netherlands), Hao Xin (University of Arizona, USA)

(SS6.1)   14:00 THz Technology for Space and Terrestrial Applications (Keynote) @!3

Peter de Maagt (European Space Agency, The Netherlands)

The terahertz (THz) part of the electromagnetic spectrum falls between the lower frequency millimeter wave region and at higher frequencies, the far-infrared region. The frequency range extends from 0.1 THz to 10 THz, where both these limits are rather loose. As the THz region separates the more established domains of microwaves and optics, a typical THz technique will incorporate aspects of both realms, and may even draw on the best of both. The two bounding parts of the spectrum also yield distinct sets of methods of generating and detecting THz waves. These approaches can thus be categorized as having either microwave or optical/photonic origins. As a result of breakthroughs in technology, the THz region is finally finding applications outside its traditional heartlands of remote sensing and radio astronomy. Extensive research has identified many attractive uses and has paved the technological path towards flexible and accessible THz systems. Examples of novel applications include medical and dental imaging, gene theory, communications and detecting the DNA sequence of virus and bacteria. The presentation will discuss the range of THz applications and will present the components and systems that are utilized for the frequency region.

(SS6.2)   14:30 Design of an Antenna Array for a Passive Mm-wave Imager $$*

Carlos Callejero (Alfa Imaging S.A., Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain)

In this paper the off-axis performance of an imaging array for an opto mechanical mm-wave imaging system has been studied. The analysed system consists of a spherical mirror and a plane polarizer. Both components are tilted to scan a vertical line. In order to avoid the beam degradation of the off-axis elements of the array a curved arrangement has been studied. The radius of this curvature has been analysed with a ray tracing program (OSLO) and a physical optics reflector antenna analysis software (GRASP) that can calculate the electromagnetic radiation of systems consisting of multiple reflectors. However, the performance achieved has been found to be similar to the performance of the planar array.

(SS6.3) **14:50 Passive Real-time Submillimetre-wave Imaging System Utilizing Antenna-coupled Microbolometers for Stand-off Security Screening Applications** $%$

Arttu Luukanen (MilliLab, Finland)

At present, the imaging of concealed weapons and contraband is primarily carried out at a relatively short stand-off range of a few meters mainly because of spatial resolution considerations. In order to maintain a reasonable aperture size, there is a desire to extend the operating frequency towards 1 THz. In this paper we report the progress on a video-rate THz camera demonstrator which utilizes broadband antenna-coupled microbolometers as detectors, operated within a turn-key commercial closed-cycle cryocooler. A full system has been integrated consisting of 64 parallel sensors and readout electronics, and reflective Schmidt camera optics incorporating a conical scanner for real time imaging. At present, the system provides near real time submillimetre-wave video imagery at 6 frames per second.

(SS6.4) **15:10 Micro-Lens Antenna for Integrated THz Arrays** $%$

Nuria Llombart (JPL, USA)

Future astrophysics experiments are expected to require large focal planes with thousands of detectors. Feedhorns have shown very good performance, but their fabrication becomes prohibitive for very large focal planes at high frequencies. A highly desirable solution to these problems would be to fabricate a monolithic array of antennas on a planar substrate. However, most planar antenna designs produce broad beam patterns, and therefore require additional elements for efficient coupling to the telescope optics, such as substrate lenses or micro-machined horns. The fabrication and assembly of such arrays is a challenge at this high frequency range. Here we present a new antenna concept that can effectively address these issues by using integrated silicon micro lenses which can be fabricated photolithographically. The antenna geometry consists of a waveguide feed, which can be integrated with Schottky mixers, that excites a silicon lens antenna through a leaky-wave or EBG resonant cavity.

(SS6.5) **15:30 Low-cost mechanically steered millimeter-wave lens antenna system for indoor LANs** $&"$

Carlos A. Fernandes (Instituto de Telecomunicaoes, Instituto Superior Tecnico, Portugal); Raul C Martins (Instituto de Telecomunicações, Portugal); Tomas Radil (Instituto de Telecomunicações, Portugal); Pedro M. Ramos (Instituto de Telecomunicações, IST, Portugal); Eduardo B. Lima (Instituto de Telecomunicações, Portugal); Carla R. Medeiros (Instituto de Telecomunicações, Instituto Superior Técnico, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE, Portugal)

The expected need in the near-future to increase the data rate of personal communication systems up to a few GBit/s, calls for the possibility to explore the millimeter wave part of the electromagnetic spectrum especially for very short range indoor radio links. High gain antennas in the order of 20 dBi are required to favor the link budget at these frequencies, but the antenna directionality limits user mobility unless at least one antenna in the link can automatically track the other antenna. A new antenna concept that is appropriate for this objective was recently developed by the authors. The objective of this paper is to demonstrate the complete concept by integrating the developed antenna with a simplified RF front-end for data transmission, along with the tracking control system and required algorithms so that a fully operational video transmission can be accomplished with this wireless mm-wave system using low-cost solutions.

PS2: Poster Session 2

(PS2.1) Fractal Negative-Epsilon Metamaterial $&&

Merih Palandoken (Technische Universität Berlin, Germany)

In this paper, a novel fractal metamaterial with negative permittivity is presented. It consists of two pairs of inductively coupled fractal Hilbert curves with antisymmetric current distribution at resonance. The resonant current distribution shows that the structure behaves as an electrically small dipole. This approach, which is different from the conventional ones, is described and the electric resonance is illustrated. The negative permittivity is derived from the numerically calculated Z-parameters. The unit cell size is only $\lambda_o/21.80$ x $\lambda_o/21.80$ at resonance. The proposed electrically small structure presents therefore a more homogeneous negative-epsilon material for "Left-handed Metamaterial" applications than the standard solutions.

(PS2.2) Sub-MM wave imager based on horn antennas with focusing lenses $&*

Yosif Pinhasi (Ariel Universoty Center of Samari, Israel); Boris Kapilevich (Ariel University Center of Samaria, Israel); Boris Litvak (Ariel University Center of Samaria, Israel); Michael Anisimov (Ariel University Center of Samaria, Israel); Ruth Arusi (Ariel Universiti Center of Samaria, Israel); Danny Hardon (Ariel University Center of Samaria, Israel)

A sub-mm system prototype is presented for imaging objects hidden under human body clothes. The system is primarily intended for in-door and out-doors homeland security applications. Its hardware is based on Rx-Tx modules operating with FMCW signal at the range 325 – 335 GHz. In order to improve spatial resolution the standard horn antennas have been integrated with focusing Teflon lenses. Computer design of such antenna system has been performed using CST Microwave Studio I-Solver. As a result the beam spot diameter about 1cm at the distance up to 2m was formed. The target imaging algorithms based on averaged-weighted procedure has been suggested for reconstructing the shape of a tested object. Examples of 2D and 3D image reconstructions are reported.

(PS2.3) Mode Matching Analysis and Design of Waveguide E-Plane Filters and Diplexers $' $

Gregory Shimonov (Tel Aviv University, Israel); Khona Garb (Tel Aviv University, Israel); Kastner (Tel Aviv University, Israel)

Implementations of wireless techniques call for low return and insertion losses and high slope selectivity of mm wave devices. Not many structures potentially satisfy all of the above criteria. In this work, diplexers with E-plane filters combined with an H-plane Y-junction splitter are investigated. The Y-junction configuration of the splitter is chosen based on its favorable S-parameter behavior. Filter analysis is facilitated using the mode matching technique (MMT). Based on this analysis, a band pass filter for the K band was built and tested. In order to integrate the filters with the Y-junction, the filters are positioned appropriately along the junction arms. The integrated filter-junction structure was then analyzed by an MMT code for the entire structure. An integrated diplexer model was built and tested, confirming the predicted performance based on the MMT.

(PS2.4)   Dual and Triple Band Patch Antennas Fed by Meandering Probe $' (

Kai Fong Lee (University of Mississippi, USA); Kwai-Man Luk (City University of Hong Kong, Hong Kong); Ka Mak (City University of Hong Kong, Hong Kong)

Patch antennas fed by meandering or M-probes have the advantage of low cross polarization, compared to the case of feeding by L-probes. In this paper, the general method of using U-slots to design dual/triple band patch antennas is applied to M-probe fed patch antennas. Several of these antennas have been fabricated and measured. Simulation results using Zeland IE3D software agree well with measured results. It is found that, in order to preserve the low cross polarization characteristics, a pair of face-to-face U-slots are needed for the dual band case while two pairs of such U-slots are required for the triple band cases.

(PS2.5)   Yagi-Uda Antennas for Terahertz Photomixer $("

Kyungho Han (Patron, Korea); Nguyen Truong Khang (Ajou University, Korea); Haewook Han (Pohang University of Science and Technology, Korea); Ikmo Park (Ajou University, Korea)

In this paper, we present THz Yagi-Uda antennas with high input impedance, achieving greatly improved impedance matching compared to existing THz antennas. We show designs employing both full-wavelength straight-line dipole and full-wavelength U-shaped dipole drivers. Current leakage into the bias line was minimized by applying photonic band gap structures at the bias line. By designing the antenna on a thin substrate, end-fire radiation patterns with high antenna resistance can be obtained even when the substrate has a high dielectric constant. We expect that the proposed Yagi-Uda antennas can achieve increased THz output power over the current state of the art.

(PS2.6)   A Broadside Radiating Holographic Antenna Excited by a Traveling Wave Patch Array $(&

Adrian T. Sutinjo (University of Calgary, Canada); Michal Okoniewski (University of Calgary, Canada)

We present a method of exciting a surface wave based hologram using a traveling-wave microstrip patch array to achieve broadside radiation. This holographic antenna may also be viewed as a periodic surface wave based leaky-wave antenna (LWA) fed by a fundamental mode microstrip LWA. Broadside radiation in the E-plane is achieved by the symmetric holographic surface. In the H-plane, broadside radiation from the patch array is attained by introducing reflection compensation sections in the microstrip line. A beam with peak radiation at broadside in both E and H-planes is achieved with 17.7 dBi antenna gain at approximately 7.7 GHz.

(PS2.7)   60-GHz Broadband Folded Dipole Array $(*

Wanli Chang (Technical University of Munich, Germany); Jiayu Luo (Nanyang Technological University, Singapore)

Nowadays antennas operated in V-band receive more and more attention as communication technology develops. Progress in material engineering opens a wide window for high frequency applications. In this paper, a broadband folded dipole antenna array is first presented, which has a magnitude of S11 lower than -10 dB over the range between 48 GHz and 64 GHz, an efficiency of 90 percent and a gain of 10 dBi. A novel configuration with a superstrate and two separate grounds is taken for improving the performance. Flip-chip connection is used between the integrated circuit carrier and the antenna attached to the superstrate.

(PS2.8)   Short-Length Leaky Wave Antenna Using Composite Right/Left-Handed Ladder Network for UHF band $) $

Shinji Kamada (National Defense Academy, Japan); Naobumi Michishita (National Defense Academy, Japan); Yoshihide Yamada (National Defense Academy, Japan)

Recently, the wideband and small size antenna for UHF band has spread into applications including mobile communications, the terrestrial digital broadcasting service, and so on. For the mobile terminal use in UHF band, resonant frequency tunable small antenna can cover wideband for the terrestrial digital broadcasting. A leaky wave antenna using a composite right/left handed transmission line (CRLH-TL) has been studied. The CRLH-TLs in microwave band using waveguide and millimeter-wave band using microstrip structure have been reported. However, there are not enough design guidelines of small leaky wave antennas for UHF band. In this paper, bandwidth and the attenuation constant of a leaky wave antenna using the CRLH-TL composed of a ladder network are discussed. The leaky wave antenna using the CRLH-TL less than one wavelength is fabricated by chip capacitors and meander inductors as the left-handed parameters. And the transmission and radiation characteristics of the fabricated antenna are measured.

(PS2.9)   Gain Enhancement of Rectangular Dielectric Resonator Antennas Fed by Dielectric Image Line $) (

Mohmmad Neshati (Ferdowsi University of Mashhad, Iran); Fatemeh Kazemi (Sistan and Baluchistan University, Iran); Farahnaz Mohanna (Sistan and Baluchistan University, Iran)

In this paper a Rectangular Dielectric Resonator Antennas (RDRA) fed by Dielectric Image Line (DIL) excited through a narrow slot is numerically investigated based on the Finite Element Method (FEM) using High Frequency Structure Simulator (HFSS) package. The effects of the ground plane width and sidewalls are studied on the radiation performance of the DRA. Return loss and radiation patterns of the antenna are presented for a specific DRA. Results show that 7.7 dB gain is obtained at 10 GHz with a broadside radiation pattern. For the DRA with four sidewalls maximum gain of 10.4 dB is achieved which is 46.4% higher than the gain of structure without them.

(PS2.10) Radiation Mechanism of H-shaped Antenna Using Parallel Resonance Mode $* "

Akiko Yamada (Graduate School of Engineering, Yokohama National University, Japan); Hiroyuki Arai (Yokohama National University, Japan)

It is required to work in various surrounding environments in order that the small antennas used for mobile terminal and RFID tag are located in the vicinity of various objects including the human body and the metal. H-shaped antenna has been proposed to obtain the characteristics not to be changed by circumference environment. In this paper, we present the mechanism of H-shaped antenna which is not changed in the presence of the metal plate near antenna elements and show the parameters to optimize the antenna performance. The H-shaped antenna has been designed by adjusting offset position and the ratio between the lengths of parallel elements. As a result of examination about the antenna height (h), the shift of input impedance near the metal was the smallest when h=0.04-wavelength.

(PS2.11) Compact Folded Monopole Antenna with LC-Loadings $*&

Seung-Han Kim (Gwangju Institute of Science and Technology, Korea); Jae-Hyung Jang (Gwangju Institute of Science and Technology, Korea)

An LC-loaded folded monopole antenna including two meander-line inductors and an interdigitated capacitor was designed for a miniaturization of antenna. The operating frequency of the antenna was essentially determined by the resonant characteristics of the uniquely arranged distributed inductors and capacitor, not by the length of the radiator, so that the size of the antenna can be designed to be very small. The radiator length of the designed antenna is 0.077-wavelength. It was also found that the effect of the size of the ground plane on the antenna performance such as resonant frequency and bandwidth is minimal.

(PS2.12) An Omni-directional Slim Polarization Diversity Antenna for Cellular Base Station $**

Hiromi Matsuno (Yokohama National University, Japan); Hiroyuki Arai (Yokohama National University, Japan); Masayuki Nakano (KDDI R&D Labs, Japan); Yoshiaki Amano (KDDI R&D Laboratories Inc., Japan); Hiroyasu Ishikawa (KDDI R&D Laboratories, Japan)

Polarization diversity is applied in wireless communication system and a slim polarization diversity antenna is required for its design conditions. In this paper, an omni-directional slim polarization diversity antenna for cellular base station is designed. The antenna configuration is optimized by E-field distribution and isolation between each polarization antenna. The vertical polarization antenna has a substrate construction and the horizontal polarization antenna has a cylindrical construction and they match well. The isolation more than 25dB is obtained in the design frequency band and the diameter of the antenna is 0.14 lambda which is smaller than that of present system.

(PS2.13) A Compact Internal Antenna on Organic Magnetic Material for DVB-H Application $+$

Yuming Song (Shanghai Amphenol Airwave Communication Electronics Co. Ltd., P.R. China)

This paper reports a compact internal monopole antenna on the novel organic magnetic material (OMM) for DVB-H applications (470-750 MHz) in a typical mobile handset with PWB dimension of 104mm 60mm. With the usage of organic magnetic material, the total size of antenna is reduced to as small as 60mm (L) 5.5mm (W) 6mm (H). Compared with antenna on conventional PC/ABS carrier, wider bandwidth and better efficiency can be achieved. The size reduction of 17% can also be achieved. The performance meets the efficiency requirement of DVB-H standard with enough margins. These properties make the design as a good candidate of internal antennas for mobile TV applications.

(PS2.14) Frequency Selective Transmission Scheme for EBG Horn Antennas $+(

Irina Khromova (Public University of Navarra, Spain); Ramon Gonzalo (Public University of Navarra, Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain); Karu Esselle (Macquarie University, Australia)

In this work a new integrated scheme of frequency selective transmission based on electromagnetic band gap (EBG) technology is presented. In the proposed configuration the radiofrequency signal is received by an EBG horn antenna and then filtered by an EBG cavity via the resonant coupling between two closed EBG waveguides and an EBG hollow defect (waveguide-to-cavity-to-waveguide coupling). The paper presents the designs of novel EBG horn antennas with competitive characteristics and demonstrates the concept of using different types of hollow EBG defects, such as point defects, void-like defects and tapers, for creating compact, efficient and integrated devices for submillimetre wavelenghts.

(PS2.15) A Compact Printed Antenna for Multiband Wireless Applications %'"

Hattan F. AbuTarboush (Brunel University, West London, United Kingdom)

This paper presents a design of a compact microstrip patch antenna with the ability of controlling the number of bands and the operating frequencies independently. The antenna comprises a main patch and four sub-patches fed by a $50\,\Omega$ microstrip line. It is designed to generate up to five separate modes to cover the frequency range from 900 MHz to 3 GHz for the operation of wireless devices supporting multiple standards including Global System for Mobile communication (GSM900, 880-960 MHz), Digital Communication System (DCS1800, 1710-1880 MHz), Universal Mobile Telecommunication System (UMTS, 1920-2170 MHz), Wireless Local Area Network (WLAN, 2400-2483.5 MHz) and low band Worldwide Interoperability for Microwave Access (WIMAX, 2.5 to 2.8 GHz) The design verified through both numerical simulation and measurement of an experimental prototype.

(PS2.16) Resolution capabilities of future THz Cameras %'&

Juan Lizarraga (Public University of Navarra, Spain); Carlos Del Rio (Public Unversity of Navarra, Spain)

THz technology for developing imaging systems has recently aroused great interest, mainly due to the large number of applications in which these frequencies can be used: security, vision in hard environments, etc. In this paper we propose a method that reduces significantly the number of detectors needed for achieving certain resolution by means of diffraction that paradoxically is its main limiting factor in current imaging devices. The method uses diffraction as a way of achieving spatial diversity and as an anti-aliasing LPF. Some examples of images are provided in the paper, showing that despite the blur created by the diffraction, it is possible firstly to sample this slow variance image, secondly, to interpolate it and finally to recover the original image.

(PS2.17) Transient Signal Analysis of Butterfly-Shaped Monopole UWB Antenna %'*

Qiubo Ye (Communications Research Centre, Canada)

The paper explores the signal distortion problem in a UWB antenna system. Theoretically, the radiated fields generated by the signal from the transmitting antenna are time derivative of the original signal. The received signals are a summation of weighted radiated fields impinged on the receiving antenna. The received signals are generally different from the transmitting one. If a transmitting signal is carefully chosen so that its time derivative resembles itself, there still exists the pulse width distortion in the received signal. An example of butterfly-shaped antenna is used to verify the theory. The asymmetrical structure and the ground plane effect also have impact on the distortion of the received signals.

(PS2.18) Improving Stop-Band Properties of Frequency Selective Surfaces with Koch Fractal Elements %#$

Robson Maniçoba (Universidade Federal do Rio Grande do Norte, Brazil); Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil); Antonio Campos (Instituto Federal de Educação Ciência e Tecnologia do Rio Grande do Norte, Brazil)

Design and experimental investigations are presented for a cascaded frequency selective surface (FSS) with perfectly conducting Koch fractal patch elements. The work was developed in two steps. In the first step two Koch fractal FSS screens were designed using the software Ansoft DesignTM and several prototypes were built. In the second step these FSS screens were cascaded and separated by an air gap layer to improve the bandwidth behaviour. The structures are cascaded using Teflon spacers and screws to obtain the air gap. The FSSs were built on a RT-Duroid 3010 substrate. Good agreement was observed between simulated and measured results.

(PS2.19) A New FSS Design Proposal for UWB Applications %#(

Rossana Cruz (Universidade Federal do Rio Grande do Norte, Brazil); Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil); Paulo Silva (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, Brazil)

This work presents a new proposal for Frequency Selective Surface (FSS) design for Ultra-Wideband (UWB) applications. The new FSSs consist of an array composed by the association of two patch elements per cell: a square loop and a crossed dipole. These structures are called Crossed Loops and have the objective of increasing the bandwidth of the square loop and the crossed dipole, when analyzed separately. Simulated results of the transmission coefficients are obtained using the Ansoft DesignerTM commercial software. Some of the FSSs tested were fabricated in order to make an experimental analysis with the measured results and to validate the new proposal. In particular, the presented results for the transmission coefficient of a built FSS prototype indicate a percent bandwidth 52.4%.

(PS2.20) Conception of a Low-Profile and High-Gain EBG Resonator Antenna with wide Bandwidth %$"

Moustapha Salah Toubet (XLIM - UMR 6172 – CNRS, University of Limoges, France); Regis Chantalat (CISTEME, France); Marc Thevenot (XLIM-UMR 6172-CNRS, University of Limoges, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Bernard Jecko (IRCOM, France)

In this paper, we present the conception of a LOW-PROFILE and High-Gain EBG Resonator Antenna which is excited by several feeds. The antenna structure has been modeled with CST MICROWAVE STUDIO, an FIT (Finite Integration Technique) based software and meets the requirements of a pre-cise specifications. It has a cut-off frequency of 1.2GHz and delivers a maximum gain of about 18 dB over a bandwidth of 59%. The size of this antenna is small in accordance with the specifications, as it is 700 mm long and wide for a very low height of 16 mm which is equivalent to λ/16. It should be noted that this antenna is being realised.

(PS2.21) Coupling Reduction in a 2x2 High Dielectric Constant EBG Patch Array %$&

JuanCarlos Iriarte (Public University of Navarra, Spain); Iñigo Ederra (Universidad Publica de Navarra, Spain); Ramon Gonzalo (Public University of Navarra, Spain); Peter de Maagt (European Space Agency, The Netherlands)

High dielectric EBG substrates can be used in patch antenna configurations to reduce size and mitigate substrate modes keeping reasonable radiation efficiency values, eff>0.55. At the same time, in array configurations they avoid grating lobes and scan blindness phenomenon at the same time, as distance and coupling between elements can be reduced. In this paper a 2x2 array configuration using these high dielectric constant (ZTT) EBG substrates is presented. The array has been fabricated and measured showing the coupling reduction achieved by the inclusion of the EBG in a configuration with a distance between elements lower than 0,5lambda. This short distance together with the coupling reduction results in a configuration which doesn't suffer from grating lobes and scan blindness problems.

(PS2.22) Modeling of a Multi-layer Conductor Magnetic Substrate on Antenna Devices %$(

Damien Rialet (IETR - University of Rennes 1, France); Ala Sharaiha (IETR-Université de Rennes 1, France); Anne-Claude Tarot (University of Rennes1, France); Christophe Delaveaud (CEA-LETI, France); Bernard Viala (CEA-LETI, France)

New materials can be obtained by combining layers that introduce the individual characteristics which one wishes to exploit (level of permeability, level of losses, etc). The association of these various materials generally forms multi-layer substrates which are complex to study. This paper aims to present simple analytical models, making it possible to evaluate an effective medium for a magneto-dielectric stacking which takes into consideration the conductivity for each layer. A model of effective permeability is showed in order to analyse the behaviour of magnetic multilayer. From this model, we can see the negative effect of the conductivity to the effective permeability of a multilayer magnetic substrate.

(PS2.23) Cylindrical Array of EBG Sectoral Antennas for Radar Applications %%'

Hassan Chreim (University of Limoges, France); Mohamad Hajj (University of Limoges, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Bernard Jecko (University of Limoges, France)

This paper presents an additional work on a previous EBG cylindrical antenna in order to conceive a steerable antenna for Radar applications which require the coverage of the horizontal plane with a high gain (higher than 25 dB). The already designed antenna provides 18 beams with 15 dBi of maximum directivity. That is why some modifications were applied on it in order to obtain more beams in the horizontal plane (30 beams) and increase its gain. Moreover, the theories of cylindrical arrays in the horizontal plane and the multi-feed in the vertical plane are used which allows further gain improvement and reaching the required one.

(PS2.24) 60 GHz Volumetric Switched Beam Array

William Moulder (The Ohio State University, USA); Waleed Khalil (The Ohio State University, USA); John L. Volakis (Ohio State University, USA)

A 60 GHz volumetrically scanning array employing a switched beam network is presented. Unlike existing switched beam networks operating at this band, the proposed network realizes volumetric scanning without using multiple switching stages. The network operates in the entire unlicensed 60 GHz band (57-64 GHz) via an innovative delay structure to compensate for the phase shift caused by the planar RF crossovers employed in the network. The network is mated with a microstrip-fed aperture coupled patch array. In this paper, we describe the beamforming network and accompanying patch array. Relevant simulation results are presented to demonstrate the RF front-end operation.

(PS2.25) Refractive index of metallic cut-wire pairs metamaterials: influence of oblique incidence

Shah Nawaz Burokur (LEME, University Paris Ouest, CNRS, EA 4416, France); Thomas Lepetit (IEF, University Paris-Sud, CNRS, UMR 8622, France); Paul-Henri Tichit (Institut d'Electronique Fondamentale - Université Paris-Sud, France); André de Lustrac (Institut d'Electronique Fondamentale - Université Paris-Sud, France)

Metamaterials made of asymmetric cut wire pairs have theoretically and experimentally demonstrated a negative refractive index at microwave frequencies. In this paper, using simulations and experiments in the microwave domain, we investigate the influence of oblique incidence on the resonances and retrieved refractive index of the asymmetric cut wire pairs. While it is found that resonances shift in frequency with increasing oblique incidence in the E-plane, it is shown that the structure is angle-independent in the H-plane. It is reported that a diffraction threshold appears in E-plane, that is the (-1,0) mode starts to propagate. Besides, resonances in E-plane shift in frequency with increasing oblique incidence.

(PS2.26) Electrically-small TE01 Mode Spherical Wire Antennas Employing Lossy Magneto-dielectric Materials

James S. McLean (TDK R&D Corp, USA); Heinrich Foltz (The University of Texas--Pan American, USA); Robert Sutton (TDK R&D Corp, USA)

It is known that a spherical wire antenna designed to radiate solely the TE01 mode exhibits higher radiation Q than does one designed to radiate solely the TM01 spherical mode, when both are unfilled and of the same size. Introduction of a magnetic core into a TE01 mode spherical wire antenna can reduce the radiation Q by reducing the magnetic energy stored in the interior of the sphere, although only to a certain extent depending on the electrical size of the sphere. Here we examine the case of a lossy magneto-dielectric core. We show that even when the magnetic material exhibits significant loss, the performance of the antenna in terms of its gain including radiation efficiency is still greatly improved.

(PS2.27) Low-Profile Design of Meta-Surface by Considering Filtering
Characteristics of FSS ％&（

Yuki Kawakami (University of Fukui, Japan); Toshikazu Hori (University of Fukui, Japan); Mitoshi Fujimoto (University of Fukui, Japan); Ryo Yamaguchi (NTT DoCoMo, Inc., Japan); Keizo Cho (NTT DoCoMo, Japan)

A FSS (Frequency Selective Surface) is composed of metal patches arranged in narrow intervals, and has frequency-band-rejection and frequency-band-pass characteristics. It is known that the FSS with the ground plane has PMC (Perfect Magnetic Conductor) characteristics in a specific frequency band. The surface is referred to as a meta-surface and it can control the phase of the wave which is reflected at the surface. This paper proposes a design method to realize a low-profile meta-surface. In the proposed method, the FSS which has low-pass or high-pass filtering characteristics is utilized. The effects of the filtering characteristics of a FSS on PMC characteristics of a meta-surface are described. Based on the calculated results, it is confirmed that the meta-surface can be obtained by using the FSS. In addition, it is found that the thinner and more wide-band meta-surface can be achieved by using the FSS which has low-pass filtering characteristics.

(PS2.28) Low Electromagnetic Coupling Bistatic Subsurface Radar Using EBG
Structures ％ "

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

EBG structures have been developed widely for reducing electromagnetic coupling. On the other hand, Bistatic radar is a system which comprises a transmitter antenna and receiver antenna. The bistatic subsurface radar is applied to detect relatively shallow structure such as tumor detection, steel reinforced detection in concrete and etc... On the other hand, the electromagnetic coupling between transmitter antenna and receiver antenna becomes problem, because, the bistatic radar detects a reflection wave from the target by the receiver antenna, therefore artifact caused by the coupling. To reduce this coupling a cavity is used, however, the cavity is not enough to reduce the electromagnetic coupling between transmitter antenna and receiver antenna. We have proposed bistatic radar system using EBG structure. In this paper, the bistatic radar system using EBG structures will be introduced briefly. And, the target detection result by using proposed bistatic radar system will be indicated.

(PS2.29) Dual UHF RFID Band Miniaturized Multipurpose Planar Antenna
for Compact Wireless Systems ％ &

Abdul Ali Babar (Tampere University of Technology, Rauma Research Unit, Finland); Leena Ukkonen (Tampere University of Technology, Finland); Lauri Tapio Sydanheimo (Tampere University of Technology, Finland)

In this paper, we will discuss the design and development of a miniaturized dual UHF band antenna, resonating on the RFID bands. The antenna resonates on 433MHz and on the European RFID band (865MHz-868 MHz).This type of planar antenna can be used in different type of small compact wireless systems, such as small RFID reader units, wireless sensor network nodes, and different indoor and outdoor wireless devices. The biggest challenge in designing such an antenna was the size of the antenna, like shorting with the ground plane and using closely coupled parallel meander line approach. The reduced size of the antenna, with an ability to resonate on multiple most commonly used frequencies with a good gain and omni-directional radiation pattern makes it a good competitor for replacing the old antenna model with the new multipurpose small, low cost antenna model.

(PS2.30) Compact shaped horn antennas in metallized foam technology % *

Anthony Rolland (IETR, University of Rennes 1, France); Ronan Sauleau (University of Rennes 1, France); Christian Person (Lab-STICC/MOM UMR CNRS 3192, France); Laurent Le Coq (University of Rennes 1, France); M'hamed Drissi UEB (INSA of Rennes, France)

We describe in this paper the synthesis of directive axis-symmetrical compact shaped horn antennas. The proposed CAD tool is based on the combination between a Finite-Difference Time-Domain (FDTD) solver in cylindrical coordinates and a genetic algorithm (GA) and can be applied to the optimisation of axis-symmetrical devices of arbitrary shapes and with arbitrary constitutive materials. A low-cost fabrication technique using a metallized foam 3-D technology is employed to manufacture horn antenna prototypes for experimental validations in Ka-band. The measurement results are in excellent agreement with the numerical predictions. Radiation efficiencies up to 89% have been obtained at 29.5 GHz.^

(PS2.31) Antenna Array System for UWB-Monopulse-Radar %($

Grzegorz Adamiuk (University of Karlsruhe, Germany); Christoph Heine (Karlsruhe Institute of Technology, Germany); Werner Wiesbeck (Karlsruhe Institute of Technology, Germany); Thomas Zwick (Universität Karlsruhe (TH), Germany)

This paper describes an antenna array configuration for the implementation in a UWB monopulse radar. The measurement results of the gain in the sum and difference mode are presented. Next the transformation of the monopulse technique into the time domain by the evaluation of the impulse response is shown. A look-up table with very high dynamic of over 25 dB and flat characteristic is obtained. The unambiguous range of sensing is approx. 40° in the angular direction. This novel combination of UWB technology and the monopulse radar principle allows for very precise sensing, where UWB assures high precision in the range direction and monopulse principle in the angular direction.

(PS2.32) Electrically Small and Efficient On-Chip MEMS Antenna
       for Biomedical Devices %((

Paulo Mendes (University of Minho, Portugal); Fabio Rodrigues (University Minho, Portugal); Luis Goncalves (Univ of Minho, Portugal)

This paper presents a novel antenna solution for application of fully integrated and ultra-small wireless biomedical microdevices. Many implantable devices require very small dimensions, making use of microtechnologies to obtain the necessary size reduction. The proposed solution uses wafer level packaging to fully integrate the antenna within the microdevice, which is based on a MEMS structure to convert the incoming electromagnetic field to a voltage. It is proposed to use a cantilever, where an electroactive material is proposed as reading mechanism. This antenna allows the reception of signals in the MHz range and uses only a chip area of 1.5x1.5 mm2, and a full system volume of 5x3x1.5 mm3.

(PS2.33) EBG band-stop filter with suppression of 3 spurious stop-bands ℅ "

Branko Kolundzija (University of Belgrade, Serbia)

Based on the well known theory of infinite periodic structures, analytical theory of EBG (electromagnetic band gap) cells suppressing 3 higher (spurious) stop-bands is developed. Each cell is in form of cascade of 6 sections (transmission lines of equal electrical length), whose characteristic impedances are strictly determined by the characteristic impedance of 2nd section (having lowest/highest value), which is decreased/increased to adjust the width of the main stop-band. Using such cells in a cascade the straight-forward procedure for design of the corresponding EBG band-stop filter is proposed. The depth of the stop-band is controlled by number of cells. The analytical theory is confirmed by the EM simulation of a filter realized in the microstrip technology and by measurement of the fabricated model.

(PS2.34) Experimental research on establishment of the tunneling mode in a pair of epsilon-negative and mu-negative by time-domain method ℅ &

Yewen Zhang (Tongji University, P.R. China); Li Zhang (Tongji University, Shanghai,China, P.R. China)

Some researchers have analyzed the properties of pairing together slabs with opposite signs for the real parts of their constitutive parameters, such as resonance, tunneling and transparency. In this paper, we try to understand the mechanism of established process of the tunneling mode with time-domain method. Phase difference between the electric field and magnetic field is studied, and variations of periods of waves during established process can be found in the pair with simulation. The energy distribution along the epsilon negative and mu negative pair also can be discussed. Experimental results based on 1D microstrip structure show good accordance with simulated results.

SS7: New Materials for Antenna Performance Enhancement-Applications and Analysis

Chairs: Raj Mittra (Penn State University, USA), Yang Hao (Queen Mary, University of London, United Kingdom)

(SS7.1) 8:30 Discrete Transformation Electromagnetics and Its Applications in Antenna Design (Keynote) ‰ *

Wenxuan Tang (Queen Mary, University of London, United Kingdom); Christos Argyropoulos (Queen Mary, University of London, United Kingdom); Efthymios Kallos (Queen Mary, University of London, United Kingdom); Yang Hao (Queen Mary, University of London, United Kingdom)

Current designs of electromagnetic cloaks are largely based on the use of metamaterials and a technique so-called "transformation optics/electromagnetics". Free space cloaks require extreme materials which are difficult to implement in practice, however, the theory of "transformation optics/electromagnetics" offers a useful design tool for antenna engineers in developing novel antennas. In this paper, a method of discrete transformation is proposed, which offers us an easy way to transform the conventional devices to the all-dielectric flat ones. A flat reflector and a flat lens antenna in the free space are designed as examples. Finite-Difference Time-Domain (FDTD) method based simulation results have proved that these simply constructed all-dielectric devices have very nice performances compared with the conventional ones, while have the advantages of flat profiles and small thicknesses.

(SS7.2) 9:00 A New Technique for the Simulation of Periodic Structures Including EBGs and Metamaterials ‰ $

Raj Mittra (Penn State University, USA); Nikhil N Mehta (Pennylvania State University, USA); Kyungho Yoo (Pennsylvania State University, USA)

The purpose of this paper is to describe a new and general-purpose technique capable of handling EBGS and MTMs, comprising of elements with arbitrary geometrical shapes and material properties. The formulation is based on a combination of the Dipole Moment (DM) method, introduced recently, and the Characteristic Basis Function Method (CBFM), which serves to reduce the size of the matrix equation to be solved via the use macro-basis functions that are physics-based and tailored for the geometry being analyzed. We show that combining the above two methods leads to a relatively small matrix, often only 2x2 or 3x3 in size for many typical elements such as split rings, dipoles and spirals and hence, renders the method numerically very efficient. A number of numerical examples will be included in the paper to illustrate the computational efficiency as well as versatility of the proposed approach.

(SS7.3)   **9:20 Manipulating Electromagnetic Radiation Through Metamaterial Structures Designed by Coordinate Transformation** %̃ &

Yijun Feng (Nanjing University, P.R. China)

In this presentation, we will demonstrate some examples of applying the transformation optics to the manipulation of electromagnetic radiations from antenna or antenna array. By designing through different kinds of coordinate transformations, the radiation direction of an omni-directional antenna could be modulated through a metamaterial cylindrical shell, and conformal antenna array located on an arbitrary curved surface could be modulated to a planar array by covering with properly designed metamaterial structure. The validity of the proposed wave manipulations have been verified through two dimensional full-wave numerical simulations based on the finite element method. The electromagnetic wave manipulation through metamaterials provides alternative ways to steer electromagnetic irradiation and may find novel applications in microwave antenna technology.

(SS7.4)   **9:40 The Magneto-electric Multipole Antenna – a New Wideband Antenna with Pattern and Polarization Diversity** %̃ *

Kwai-Man Luk (City University of Hong Kong, Hong Kong); Biqun WU (City University of Hong Kong, P.R. China)

A wideband four-port integrated antenna that is capable of exciting four different radiation patterns is presented. The antenna designated as the magneto-electric multipole consists of four dual-polarized magneto-electric dipoles arranged in a 2 by 2 array configuration above a ground plane. A two layer matching network is used to combine the signals from the four dual-polarized dipoles to produce two orthogonal broadside modes and two orthogonal conical modes. The performance of the proposed antenna is studied computationally. It can achieve about 27.2% overlapped bandwidth with the centre frequency of 3.9GHz. The isolation between any two ports is greater than 15dB. The two orthogonal broadside modes exhibit about 12 dBi average gain. While for the two orthogonal conical modes, an average gain of 7 dBi can be achieved. The measured radiation patterns of the four degenerate modes are stable within the operating band.

(SS7.5)   **10:00 Broadband Superlensing using a Metamaterial with an Extreme Index of Refraction: Salient Features, Physical Principles and Analytical Modeling** %̃ $

Mario Silveirinha (Universidade de Coimbra - Instituto de Telecomunicações, Portugal); Carlos A. Fernandes (Instituto de Telecomunicaoes, Instituto Superior Tecnico, Portugal); Jorge R. Costa (Instituto de Telecomunicações / ISCTE, Portugal); Carla R. Medeiros (Instituto de Telecomunicações, Instituto Superior Técnico, Portugal)

In a recent work [M. G. Silveirinha, C. A. Fernandes, J. R. Costa, Phys. Rev. B, 78, 195121, 2008], we have theoretically demonstrated that a micro-structured material formed by a very dense array of crossed wires can be used to enhance the near-field and achieve subwavelength imaging. Here, we describe our ongoing work in this topic, and discuss the physical principles and the salient features of the imaging mechanism. Using a homogenization formalism we study the imaging of two electrical line sources by the dense array of crossed wires and demonstrate that the two sources can be distinguished at a significant distance from the source plane.

(SS7.6) **10:20 Electro-Textile Printed Slot Antenna over Finite EBG Structure** %+(

Joao Vicente (IST - Tech University of Lisbon, Portugal); Antonio A Moreira (I.S.T. - Technical U. Lisbon / I.T. Lisbon, Portugal)

This paper reports an electro-textile antenna fed by a thin coaxial cable, based on a monopole like element and a rectangular slot with a triangular transition on a ground plane. The structure resembles a printed slot antenna with two electro-textile layers and common felt used as dielectric. Prototypes were fabricated and measured for an isolated antenna and in the vicinity of a user's limb. The antenna was designed for central frequency 2.45 GHz. A simplified simulation model was used to emulate the effect of the user's limb on the antenna performance. To improve antenna radiation and total efficiency an EBG inspired structure was included in the design. The new structure was numerically simulated and measured in wearing scenario in the vicinity of the human body.

PS3:   Poster Session 3

(PS3.1)   A Deconvolution Method to Remove Distortion Caused by Antenna Radiation Pattern from Measurement &" "

Huajian Cui (Polytechnic Institue of Leiria, Portugal); Rafael F. S. Caldeirinha (Polytechnic Institute of Leiria, Portugal); Jürgen Richter (University of Glamorgan, United Kingdom)

The influence of vegetation on radiowave signals has become an important aspect of the design of wireless communication links. In recent years the theory of Radiative Energy Transfer has been adopted as a reliable tool to predict the radiowave propagation through and near vegetation. However one major factor influencing accuracy of the measurement is the radiation pattern of the receiver antenna. The measured pattern will be the convolution of the antenna radiation pattern and the phase function of the vegetation medium. The measured pattern therefore needs to undergo a deconvolution process before enable to provide reliable information. This paper presents a deconvolution method developed using optimum compensation filtering to remove the distortion caused by the receiver antenna radiation pattern. A pre-filtering technique using auto/cross-correlation is utilised to improve the deconvolution results, as well as an error function is deployed to determine the optimal parameter in the iterative filter.

(PS3.2)   Optimization methods for computer-Aided Design of artificial dielectric lens antennas &" &

Arij Farhat (TELECOM Bretagne, France); Eddy Jehamy (Auto-Cruise, France); Michel Ney (TELECOM Bretagne Institute, France)

ABSTRACT: The paper investigates the optimization of an electrically large antenna: a shaped dielectric substrate lens at millimeter wave frequencies (76 - 77 GHz). The aim is to determine the best lens profile that complies with arbitrary desired radiation pattern templates. A feed forward artificial neural network (ANN) was implemented in order to predict the radiation pattern of this antenna. Particle Swarm Optimization (PSO) procedure, combined with neural network modeling, is applied in order to minimize the cost function (the fitness function) and to fit specifications. The optimized results are in a good agreement with 3D MoM simulations.

(PS3.3)   Smart Card with an Integrated Electrical Switch for Secure Operation &" *

Jong Won Yum (Gwangju Institute of Science and Technology, Korea); Jae-Hyung Jang (Gwangju Institute of Science and Technology, Korea)

Security concerns and privacy infringement can be serious problems in many applications of radio frequency identification (RFID) systems. Most of the problems are due to the lack of user control over the communication between RFID tags and readers. Giving the user control over the RFID link can alleviate potential security problems. A simple smart card that prevents unauthorized credit card payment or unwanted identification theft can be realized by integrating a simple electrical touch switch with a 14443 smart card. The smart card is activated only when the user touches the switch; specifically, the impedance of an interdigitated capacitor changes at the touch of a finger.

(PS3.4) Intracavitary Microwave Thermal Therapy for Bile Duct Carcinoma - Experimental Evaluations on Heating Performances of Antenna &#$

Kazuyuki Saito (Chiba University, Japan); Kousuke Tsubouchi (Chiba University, Japan); Masaharu Takahashi (Chiba University, Japan); Koichi Ito (Chiba University, Japan)

Microwave thermal therapy is one of the modalities for cancer treatment. There are several schemes of microwave heating. The authors have been studying thin coaxial antenna for intracavitary microwave heating aiming at the treatment of bile duct carcinoma. Up to now, the heating characteristics of the antenna are investigated by numerical simulation and experiment using a tissue-equivalent phantom. In this study, temperature rises around the antenna inserted into an actual liver tissue of swine are measured. As a result of the measurement, relation between effective heating region and input power to the antenna was found.

(PS3.5) Development of an Implanted Helical Folded Dipole Antenna &#(

Hayato Mizuno (Chiba University, Japan); Masaharu Takahashi (Chiba University, Japan); Kazuyuki Saito (Chiba University, Japan); Koichi Ito (Chiba University, Japan)

Small implanted devices have been investigated with great interest for wireless medical applications due to the promise of different clinical usages in order to promote patient's independence. In these implanted device systems, an antenna plays an important role as a part of transmitting and receiving power. Therefore, the research on the antenna for implantable device (implanted antenna) is important. In this study, we propose an implanted helical folded dipole antenna for short-range wireless communications. The antenna is designed to operate at 2.45 GHz, one of the industrial-scientific-medical (ISM) bands, and it is investigated by use of the finite-difference time-domain (FDTD) calculation. We have analyzed some performances of the proposed antenna and the results show that the proposed antenna can be a candidate as an implanted antenna.

(PS3.6) Sectoral Metallic EBG Antenna for High Data Rate Wireless Terrestrial Communications with Vehicles using Mobile WiMAX Technology &$"

Dina Serhal (University of Limoges, XLIM laboratory, France); Regis Chantalat (CISTEME, France); Mohamad Hajj (University of Limoges, France); Thierry Monediere (XLIM-UMR 6172-CNRS, University of Limoges, France); Bernard Jecko (University of Limoges, France)

This paper introduces a new model of high gain sectoral metallic Electromagnetic Band Gap antenna used to communicate with mobile vehicles such as cars, trains, etc. This antenna, which is dedicated to base stations, aims at providing high data rate for passengers so that they can connect to Internet during their travel using mobile WiMAX technology. The proposed antenna is composed by a rigid metallic structure designed especially to be suitable with base station pylons. It is designed using the multisource technique. Simulations show the high performances of the antenna especially in terms of gain and bandwidth. Finally, a prototype is realized and a set of measurements validate simulation results.

(PS3.7) **Design and Diversity Performance of Optimized Dual-Element PIFA antennas for MIMO Handsets** &$&

Qiong Wang (Dresden University of Technology, Germany); Dirk Plettemeier (Dresden University of Technology, Germany); Hui Zhang (Dresden University of Technology, Germany); Klaus Wolf (Dresden University of Technology, Germany); Eckhard Ohlmer (Technische Universität Dresden, Germany)

An optimized multiple-input-multiple-output (MIMO) antenna system is proposed. It is based on the traditional planar inverted-F antenna (PIFA) design, accommodated on a printed circuit board (PCB) for mobile handsets and operating at 2 .6GHz. The PIFA dimension is reduced by 30% with meander structure etched on the conventional PIFA. Diversity performances of a parallel dual-element Meander PIFA array are evaluated in different statistical propagation environments for both without chassis and with chassis configurations. It is found that an optimized Meander PIFA with chassis can still keep nearly the same good diversity performance as the case without chassis. It has also been shown that the dual-element Meander PIFA can work well in different statistical environments.

(PS3.8) **Development on Flexible Hand Phantom and its Application to Impedance Measurement of Antenna for Mobile Radio Terminal** &$*

Takumi Hiraoka (Chiba University, Japan); Kazuyuki Saito (Chiba University, Japan); Masaharu Takahashi (Chiba University, Japan); Koichi Ito (Chiba University, Japan)

Recently, mobile phones have been downsized increasingly and the antenna is embedded inside. In general, the characteristics of the antenna are influenced by a body of user. The influence of the hand on mobile phone is considered to be very important in designing the antenna. So far, the influence of the hand on the antenna has been investigated by use of a hand phantom, which has same electrical properties as the body and a particular shape. In this study, the authors have developed a hand phantom which can change its shape arbitrarily. Moreover, the S-parameter of the antenna gripped by the developed hand phantom was measured to show the effectiveness of the developed hand phantom.

(PS3.9) **Using a Multilayer Perceptrons for Accurate Modeling of Quasi-Fractal Patch Antennas** &%$

Elder Oliveira (Universidade Federal do Rio Grande do Norte, Brazil); Paulo Silva (Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, Brazil); Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil)

A multilayer perceptrons (MLP) artificial neural network (ANN) with one hidden layer and trained through the efficient resilient backpropagation (RPROP) algorithm is used for modeling quasi-fractal patch antennas. The design of the proposed antenna is based on the application of rectangular Koch fractal curve to the edges of a conventional microstrip inset-fed patch antenna. The electromagnetic (EM) characterization of the patch antennas was performed using the Ansoft DesignerTM software that uses the method of moments. A parametric analysis was developed as function of the dielectric substrate thickness and size of the quasi-fractal patch antennas. Considering the region of interest of the design parameters a representative EM-dataset was obtained to develop the MLP network model using the conventional EM-ANN neuromodeling technique. The MLP model is able to estimates the behavior of the antennas with very good accuracy and low computational cost. Good agreement is observed between simulated and measured results.

(PS3.10) Taper transitions between two rectangular waveguides via transformation optics

Paul-henri Tichit (Institut d'Electronique Fondamentale - Université Paris-Sud, France); Shah Nawaz Burokur (LEME, University Paris Ouest, CNRS, EA 4416, France); André de Lustrac (Institut d'Electronique Fondamentale - Université Paris-Sud, France)

Spatial coordinate transformation is a suitable tool for the design of complex electromagnetic structures as already shown for cloaks, concentrators, beam bends and expanders, rotators, channels and directive antennas. In this paper, we define three spatial coordinate transformations that show the possibility of designing a taper between two different waveguides. The media obtained from these three methods present complex anisotropic permittivities and permeabilities. A parametric study is presented for the three transformations and we propose achievable values of permittivity and permeability that can be obtained with existing metamaterials. The performances of such defined structures are demonstrated by finite element numerical simulations.

(PS3.11) A Reconfigurable Planar Antenna Array (RPAA) with Back Lobe Reduction

Mohd Tarmizi Ali (Universiti Teknologi Malaysia, Malaysia); Tharek Abdul Rahman (Wireless Communication Centre, Malaysia); Muhammad Ramlee Kamarudin (Universiti Teknologi Malaysia, Malaysia); Ronan Sauleau (University of Rennes 1, France); Mohd Nor Md Tan (University Technology Malaysia, Malaysia)

A novel structure of Reconfigurable Planar Antenna Array (RPAA) added with a microwave absorber is designed. This antenna is consists of two elements structure, which are the 16-element microstrip rectangular patch antenna structures (top) and the separated feed line structure (bottom). The unique property of this antenna design is that instead of fabricating all together in the same plane, the antenna's feeding network is separated from the antenna radiating elements by an air gap distance. This antenna is integrated with RF switches to produce the scanning beam pattern to desired direction. The additional material was proposed involves placing a microwave absorber material such as ECCOSORB@ at the back of the top substrate. The ECCOSORB is useful for suppression of unwanted radiated field and thus improved the back lobe pattern at an average of 10 dB. The simulated results are presented to demonstrate the excellent performance of this antenna.

(PS3.12) A Dual Feed PIFA Diversity Antenna for MIMO Systems

Hassan Chattha (University of Liverpool, United Kingdom); Yi Huang (University of Liverpool, United Kingdom); Xu Zhu (University of Liverpool, United Kingdom); Yang Lu (University of Liverpool, United Kingdom)

This paper presents a novel dual-feed Planar Inverted-F Antenna (PIFA) for MIMO radio communication systems at 2.45 GHz. This antenna contains only one radiating plate with two matched and isolated ports. To reduce the mutual coupling and to achieve a good isolation, ground plane under the top radiating plate is etched. The calculated envelope cross-correlation is less than 0.02 and the ratio of the mean effective gain between the two ports is close to unity. It is shown that a single PIFA antenna can be used instead of two antennas for diversity gain which is an excellent solution for saving the space and cost. Simulated and measured results are provided to verify the conclusion.

(PS3.13) Dual Frequency Selective Reflectarray for Propagation Improvement &&*

Tamami Maruyama (NTT DoCoMo, Inc., Japan); Tatsuo Furuno (NTT DoCoMo, Inc., Japan); Tomoyuki Ohya (NTT DoCoMo, Japan); Yasuhiro Oda (NTT DoCoMo, Japan); Qiang Chen (Tohoku University, Japan); Kunio Sawaya (Tohoku University, Japan)

This paper proposes a novel dual frequency selective reflectarray for beam control of scattered wave to eliminate propagation blind zones. The design requirement of the reflectarray is that the scattered wave directions at dual frequencies can be controlled independently using two different polarizations, and incident wave of at other frequency can pass through the reflectarray. To meet this requirement, reflectarray composed of the cross dipole array on the top surface and double square loop on the bottom surface as dual frequency selective surface is proposed. A reflectarray operated at 8.75 GHz and 17.5 GHz is designed in order to control 30 degree beam direction. Measurement and finite element analysis are performed to confirm the capabilities of dual frequency selection and the control of the directions of scattered beams depending on wave polarizations.

(PS3.14) Development of Tunable Head Local Exposure System for Rats Using Rectangular Loop Antenna in 3.4 GHz Band &' $

Daisuke Usui (National Institute of Information and Communications Technology, Japan); Takuji Arima (Tokyo Univesity of Agriculture and Technology, Japan); Hiroki Kawai (National Institute of Information and Communications Technology, Japan); Kanako Wake (National Institute of Information and Communications Technology, Japan); Soichi Watanabe (National Institute of Information and Communications Technology, Japan); Toru Uno (Tokyo University of Agricultural Technology, Japan)

The aim of this study is to develop an animal exposure system for investigating biological effects of local exposure to microwaves from mobile phones. Currently, new mobile communication systems using a 3.4 GHz band are being developed. Therefore, it is necessary to investigate the biological effects of microwaves in this frequency band. In this paper, an exposure system using a rectangular loop antenna is proposed for investigating the biological effects of microwaves in the 3.4 GHz band. The proposed antenna has a simple structure and can be tuned to a resonant frequency between 3.3 and 3.8 GHz by changing the feed point. Numerical dosimetry result shows good locality for 2-4 week-old rat model.

(PS3.15) Effects of Substrate on the Performance of Photoconductive Antennas &' (

Di Li (University of Liverpool, UK, United Kingdom); Yi Huang (University of Liverpool, United Kingdom); Yao-Chun Shen (University of Liverpool, United Kingdom)

Photoconductive antennas have been widely used to generate and detect THz waves in recent years. Because the thickness of the substrate is usually larger than the wavelength of THz waves and surface/substrate modes may be generated, the effect of the substrate cannot be ignored. This paper is therefore to investigate this problem using a numerical simulation tool. The radiation pattern and power of photoconductive antennas with different sizes of substrates are obtained. The results show that the most power is radiated towards the substrate side rather than the free space; a thin substrate is preferred to maximise the radiated power and control the radiation direction.

(PS3.16) Design of UTeM antenna &("

Dalila Misman (Universiti Teknikal Malaysia Melaka, Malaysia); M. Z. A. Abdul Aziz Zoinol Abidin (Universiti Teknikal Malaysia Melaka, Malaysia)

UTeM antenna that are form by Meander Line Antenna (MLA) has been designed to operate at 2.4-GHz. By adding parasitic element, a better return loss can be achieved. As the degree of parasitic α is increased, the frequency has a small changes and the bandwidth increased from 48 to 70 MHz but he directivity seems to decrease from 9.64dBi to 4.94dBi as the degree increase from 30 to 270 degree (for planar antenna). The antenna is fabricated on a double-sided FR-4 printed circuit board using an etching technique. The measurement results for planar antenna designs shows operating frequency at 2.51GHz with -13.52dB of return loss. The bandwidth is 70MHz start from 2.48GHz to 2.52GHz. The antenna gain is 3dB. The measurement result for UTeM microstrip antenna shows that the operating frequency is 2.45 GHz with -13.36dB of return loss.

(PS3.17) Analysis of Space Coverage in Far Field UHF RFID Systems &(&

Branko Mrdakovic (WIPL-D, Serbia); Branko Kolundzija (University of Belgrade, Serbia)

In this paper, a new method for analysis of space coverage in UHF RFID systems is presented. The method is based on EM modeling of tags and reader antennas in desired RFID environment and post-processing of near field data taking into account arbitrary positions and orientations of tags. The method is illustrated for a case when collection of objects pass through the concrete gateway using one to three reader antennas in "AND" and "OR" scenario. Thanks to results that are obtained by using this method, it is possible to select tags, configuration of RFID system and protocol for communication between reader and tag which will obtain fully coverage.

(PS3.18) Characterization of the underground mine mobile channel using Power Spectrum Analysis &(*

Manani Moboladji Moutairou (Laval University, Québec, Canada, Canada); Gilles Y. Delisle (University of Ottawa, Canada)

Wireless network operators are dealing with complex problems when planning network operations, particularly in an underground environment. To permit an acceptable level of automation in the planning process, simulation and optimization tools are being developed using various approaches. This paper reports results from a measurement campaign aimed at extracting important parameters which help to characterize the underground mobile radio channel. The measurement procedure is clearly presented and the effects of this difficult channel on a specific signal generated by a signal generator are analyzed. The attenuation [1-2] factor and the path loss exponent along various routes are observed and propagation profiles are recorded at level 70m below ground at experimental mine CAMNET located in Val d'Or, Québec, Canada.

(PS3.19) Active Throughput Measurements for Complete MIMO WLAN Systems using Dual Reverberation Chamber Technique &) $

Naveed Aijaz (Chalmers University of Technology, Sweden); Charlie Orlenius (Bluetest AB, Sweden); Magnus Franzén (Bluetest AB, Sweden); Mats Andersson (Bluetest AB, Sweden);

A reliable, repeatable and fast measurement procedure for a complete Multiple-Input-Multiple-Output (MIMO) Wireless Local Area Network (WLAN) system is presented. Application level throughput is presented as a performance metric to reflect the actual throughput delivered to the end user by a WLAN system. The employed technique involves the use of two reverberation chambers to cope with the real world scenario of low Signal to Noise Ratio (SNR) proximity and to effectively control the rank of a communication channel. The procedure uses test parameters based on standard test specifications, which makes it reliable and easy to reproduce. The test repeatability is shown to be very high, due to small standard deviation between measured results for similar test cases. This test procedure provides uncomplicated control not only over the test parameters but also over the channel characteristics thus providing a wide span of test scenarios.

(PS3.20) An Investigation on the Performance of Receiving Optical Beam-Forming Networks &) (

Mostafa Shabani (Sharif University of Technology, Iran); Mahmood Akbari (Sharif University of Technology, Iran)

Next generation wideband and ultra-wideband radar antenna arrays need efficient true-time delay networks for array control. Following the great interest for optical control of antenna array beam steering, performance analysis of optical beam-formers is a must. In this paper signal to noise ratio and dynamic range of simple optical beam-forming structures with components off the shelf are investigated theoretically. Especially the effects of certain power combining components such as arrayed wave guide gratings, broadband passive optical combiners and microwave combiners inspected. It turns up that an efficient microwave combiner would surpass the optical combiners in both SNR and dynamic range.

(PS3.21) Numerical Approach for the Fast Analysis of Radiation Patterns of Antennas in Complex Environments &*"

Carlos Delgado (Alcala University, Spain)

A numerical technique for the analysis of the radiation pattern of antennas which interact with complex structures is presented in this work. Different parts of the geometry, called windows, are isolated and the primary currents due to the external excitations are obtained. In the next steps, we compute the interactions between different parts of the geometry and update the total currents in an iterative way. The approach stops when the computed error fulfills the requirements or when the maximum number of interactions has been reached. This method is especially well suited for problems that lie beyond the scope of both rigorous and high-frequency conventional techniques, due to computational and/or accuracy requirements.

(PS3.22) Study of Reconfigurable Antennas for MIMO Systems &* &

Fizzah Mubasher (Queen Mary University of London, United Kingdom); Shihua Wang (Queen Mary University of London, United Kingdom); Xiaodong Chen (Queen Mary, University of London, United Kingdom); Zhinong Ying (Sony Ericsson Mobile, Sweden)

This paper presents our initial study on a novel reconfigurable MIMO slot antenna to achieve pattern diversity and therefore improve the system performance. The MIMO antenna consists of two identical reconfigurable slot antennas which are separated by a distance of less than quarter wavelength designed at the frequency of 5.2 GHz suitable for WLAN applications. Each of the slots can be reconfigured in their length by switching on/off the shorting pins within it. The configurations of these shorting pins affects the mutual coupling between the array elements and this leads to pattern diversity which can be used to achieve the optimal capacity of the MIMO channel.

(PS3.23) Analysis of a Dual-Band Reflectorarray by Using a Full Wave Moment Method Code &* *

Josefa Gómez Pérez (Universidad de Alcalá, Spain); Abdelhamid Tayebi (University of Alcala, Spain); Iván González Diego (Universidad de Alcalá, Spain); Felipe Catedra (University of Alcala, Spain)

This work presents an efficient and powerful approach for electromagnetic field analysis of complex 3D bodies. The method is able to provide fast and accurate analysis of arbitrary metallic and dielectric/magnetic structures, and combines the Moment Method (MM), the Multilevel Fast Multipole Algorithm (MLFMA), Physics Optics (PO) and the Characteristics Basis Function Method (CBFM) to solve very large scattering problems. Moreover, in order to minimize memory and time requirements, a parallelization process has been carried out by using the Message Passing Interface (MPI) algorithm. The code has been validated in many applications providing accurate predictions compared with measurements. As an example, a dual-band reflectarray is analyzed to check the performance of the proposed code.

(PS3.24) A New Compact Koch Fractal Patch Antenna on an EBG Ground Plane &+$

Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil); Elder Oliveira (Universidade Federal do Rio Grande do Norte, Brazil); Ronaldo Martins (Federal University of Rio Grande do Norte, Brazil); Antonio Campos (Instituto Federal de Educação Ciência e Tecnologia do Rio Grande do Norte, Brazil)

A new antenna with Koch fractal patch elements of the first level (KR1) and electromagnetic bandgap in the ground plane (EBG-GP) is proposed in this paper. The design is based on Ansoft HFSSTM software and in order to validate the model several prototypes are built and measured. A better impedance matching for the device is obtained using the inset-fed technique. The measured return loss values for the proposed antennas at the resonant frequencies are lower than -20 dB. The KR1 EBG-GP antennas show corresponding resonant frequencies values lower than the rectangular patch antennas with inset-fed. That results in a size reduction factor around 28% for these structures resonating at 2.45 GHz.

(PS3.25) Channel model for on body communication along and around the human torso at 2.4GHz and 5.8GHz &+(

Anda Guraliuc (University of Pisa, Italy); Paolo Nepa (University of Pisa, Italy); Giuliano Manara (University of Pisa, Italy); Andrea Serra (University of Pisa, Italy)

A new trend in developing wireless sensors consists in using wearable wireless sensors to monitor human vital parameters, activities and movements. Characterizing the radio channel is an important issue to design a suitable communication system, especially when the propagating medium is the human body. To address this problem, on body measurements along and around the torso were performed. Two path loss models were analyzed considering the propagation channel characterization between two wearable devices placed on a human body, and operating at 2.4GHz and 5.8GHz. Wearable wireless low-cost commercial modules and low profile annular ring slot antennas were used as transceivers Measurement results were compared with CST Microwave Studio simulations using simplified body models like spherical and ellipsoidal geometries.

(PS3.26) RFID Tag Antenna for Use on Metal ' " "

Xiaohui Tao (Shanghai Jiao Tong University, P.R. China); Junping Geng (Shanghai Jiaotong University, P.R. China); Rong Hong Jin (Shanghai Jaio Tong University, P.R. China); Xianling Liang (Shanghai Jiaotong University, P.R. China); Hao Wu (Shanghai Jiao Tong University, P.R. China)

A new RFID tag planar antenna is developed, which performs well on metallic objects. Unlike earlier attempts to resist the effect of metal with absorbing and isolating materials, this approach introduces a special structure—"Multi-Layers", and the newly-invented Adaptive Comprehensive Learning Particle Swarm Optimization (A-CLPSO) is implemented in the process of the antenna design. Moreover, with specially-designed algorithms, both the radiation part and the middle ground part are continuous structure without point contact. The overall size of the optimized antenna is 70*50*4 mm3. The simulated and experiment results are shown, which meet the demand of Chinese RFID standard.

(PS3.27) A Comparative Study of Three Ultra-Wideband Log-Periodic Microstrip Antenna Arrays ' " &

Valdez Filho (Universidade Federal do Rio Grande do Norte, Brazil); Paulo Silva (Federal Institute of Education, Science and Technology of Paraíba, Brazil); Adaildo Assunção (Universidade Federal do Rio Grande do Norte, Brazil)

This paper described the design, simulation and fabrication of three ultra-wideband log-periodic microstrip antenna arrays. A comparative study is presented between arrays using rectangular, square and circular patch elements and varying the number of elements (5, 10 e 15). Electro-magnetically coupled microstrip patches had been used as radiating element of arrays. The frequency responses of these arrays are analyzed using the Ansoft Designer™ commercial software that implements the method of moments. After the simulations were completed, three prototypes were constructed and measured using a vector network analyzer. The results for the -10 dB return loss bandwidth of the antenna arrays are presented. The good agreement between the oretical and experimental results for the built antenna prototypes validated the used methodology.

(PS3.28) Compact DVB-T Printed Monopole Antenna ' " *

Xianling Liang (Shanghai Jiaotong University, P.R. China); Ronghong Jin (Shanghai Jiao Tong University, P.R. China); Yue Zhao (University of Shanghai Jiaotong, P.R. China); Junping Geng (Shanghai Jiaotong University, P.R. China)

With advent of the next generation communication, the digital video broadcasting is widely used and has been brought to mobile situations, such as the car DVB-T receiver. This practical application commonly requires the antenna covering the frequency range of 470- 862 MHz with a low profile and a simple structure. For this purpose, this paper introduces a wideband printed monopole antenna design, which is based on two techniques, the resistor-loaded technique and the wideband impedance matching. The results show that the proposed antenna achieves a DVB-T bandwidth of gains better than -6dBi, with a stable omni-directional radiation and a low profile.

(PS3.29) A Novel Feeding Technique for Ka-Band Horn Antenna ' #$

Ali Othman (Universiti Sains Malaysia, Malaysia); Mohd Ain (Universiti Sains Malaysia, Malaysia); Ahmad Asari Sulaiman (Universiti Sains Malaysia, Malaysia)

A practical horn antenna feeding configuration for use at Ka-band frequencies is proposed. It is consists of five circular identical cylindrical parasitic dielectric resonator (DR) fed by a microstrip feedline through a coupling rectangular slot in the ground plane between them. It is designed to parasitic type for high gain, high isolation and wideband characteristics. The bandwidth enhancement is achieved for the HEM11δ mode with the parasitic resonators superimposed on driven DR. Excellent return loss and radiation characteristics of DR in HEM11δ were observed. CST simulation results of the electrical performance for pyramidal horn antenna operating at 38GHz are presented.

(PS3.30) Reconfigurable meander antenna for DVB-H band ' #(

Florian Canneva (LEAT, France); Jean-Marc Ribero (Université de Nice Sophia Antipolis, France); Robert Staraj (University of Nice-Sophia Antipolis, France)

This paper presents an active antenna dedicated to the mobile TV standards DVB-H, T-DMB or DVB-SH. This meander antenna uses PIN diodes inserted in different points of the radiating element to dynamically cover the frequency band needed for these standards with a sufficient bandwidth. The insertion of active components allows to compensate the drawback of the small volume of this miniature antenna even if it decreases the efficiency. To solve the problem of the efficiency we can use switch MEMs which have better electric properties. This novel radiating structure has been developed within the NAOMI project supported by the french ANR (National Agency for the Research).

(PS3.31) Acceleration of Spectral Domain Analysis Method for Conformal Antennas ' $"

Zvonimir Sipus (University of Zagreb, Croatia); Marko Bosiljevac (University of Zagreb, Croatia); Juraj Bartolic (University of Zagreb, Croatia)

This paper presents different approaches for acceleration of the spectral domain analysis of large conformal antennas and arrays. The basic idea is to find suitable simplification of the original problem that can be efficiently analyzed using alternative method like Uniform Theory of Diffraction (UTD). Then by applying the asymptotic extraction technique to the spectral domain analysis method we can overcome the problems that are encountered when spectral domain method is applied to structures with dimensions large in terms of wavelength. The technique was demonstrated on several test cases showing promising results and it is the first step in the development of a more general analysis approach for arbitrary shaped conformal antennas.

(PS3.32) A low cost dual-band adaptive antenna tuning module for mobile phones ˈ $&

Kevin Boyle (EPCOS, Netherlands); Theo Bakker (EPCOS, Netherlands); Maurice de Jong (EPCOS, Netherlands); Andre van Bezooijen (EPCOS, Netherlands)

This paper presents a simple, low cost adaptive antenna tuning module that is used in conjunction with a typical mobile phone antenna. It is shown that the transmit and receive VSWR can be substantially improved over the frequency ranges 824-960 and 1710-2170 MHz with and without the effect of the user's head and hand.

IP1: Industry Panel - Challenges in Mobile Communication Antenna Design

Chair: Dirk Manteuffel (University of Kiel, Germany)
Panel Members: Brian Collin (Antenova, UK), Kevin Boyle (EPCOS, UK), Oliver Klemp (Delphi, Germany)

(IP1.1) Redefining the impossible @!3

Brian Collins (Antenova, U518BK)

(IP1.2) Reconfigurable antennas for mobile phones @!3

Kevin Boyle (EPCOS, U519BK)

(IP1.3) Vehicular Communications - Current Trends and Challenges in Automotive Antenna Engineering @!3

Oliver Klemp (Delphi, Germany)

SS8: **Miniaturized MIMO and Multiple Antennas**

Chairs: Cyril Luxey (University of Nice, France), Dirk Manteuffel (University of Kiel, Germany)

(SS8.1) **15:15 Highly-efficient Multiple Antenna-systems for Small MIMO Devices (Keynote)** ' $*

Cyril Luxey (University of Nice, France); Dirk Manteuffel (University of Kiel, Germany)

Today, every small communicating device must be able to wirelessly transfer or receive high data rates. Consequently there is a strong demand to design multiple antenna-systems able to efficiently operate in diversity or Multiple-Input-Multiple-Output modes. In this paper, we propose to focus on highly-efficient multiple antenna-systems for small MIMO devices. First, we perform a state-of-the art review of the best solutions developed by various researchers. Then, we present lots of multiple antenna-systems designed at the LEAT of the University of Nice-Sophia Antipolis since 2004. We especially describe our technique dedicated to enhance the total efficiency of several radiators when they are closely placed over the same small ground plane. Last, we try to identify promising solutions and future trends in this area.

(SS8.2) **15:45 Diversity Mechanisms and MIMO Throughput Performance of a Compact Six-Port Dielectric Resonator Antenna Array** ' %&

Vanja Plicanic (Lund University, Sweden); Meifang Zhu (Lund University, Sweden); Buon Kiong Lau (Lund University, Sweden)

This paper demonstrates multiple-input-multiple-output (MIMO) throughput performance of a six-port dielectric resonator antenna (DRA) array for Wireless-LAN applications in a measured indoor office environment when a six-port dual-polarized patch array is used at the transmitter. The throughput was obtained using an IEEE802.11n/ Draft 5.00 simulator for measured channels with different antenna and propagation setups. The throughput performance of the patch-DRA array set-up is found to be similar to that of a set-up with six-port monopole arrays at the receive and transmit ends in the non-line-of sight (NLOS) environment. The compact design of the DRA array causes lower port efficiencies relative to those of the monopole array, notwithstanding the compact DRA array is shown in this paper to effectively utilize angle, polarization and spatial diversity mechanisms to achieve comparable throughput performance.

(SS8.3) **16:05 Investigating Redundancies in reconfigurable antennas designed for MIMO systems** ' %*

Joseph Costantine (University of New Mexico, USA); Christos Christodoulou (University of New Mexico, USA); Alfred Grau (University of California, Irvine, USA); Franco De Flaviis (University of California, Irvine, USA)

In this paper we investigate a new approach in optimizing the number of switches in reconfigurable antennas designed for MIMO (Multiple Input Multiple Output) applications. This optimization technique is based on graph modeling reconfigurable antennas which leads to removing redundant parts from the antenna structure. One of the main objectives of this technique is to reduce the number of electronic elements used in a reconfigurable antenna such as switches to reduce costs and losses added by these elements. A specific multifucntional MEMS (Micro Electro Mechanical Systems) reconfigurable antenna example is presented and analyzed to prove the validity of the new approach.

(SS8.4)   **16:25 Evaluation of Compact Antenna Arrays for Mobile Communications Applications ' &$**

Christian Volmer (Ilmenau University of Technology, Germany); Ralf Stephan (Technische Universität Ilmenau, Germany); Matthias Hein (Ilmenau University of Technology, Germany)

Mutual radiator coupling is known to impair the performance of modern multi-antenna communications concepts, such as diversity or MIMO. In order to facilitate the development of highly compact designs for mobile consumer applications, we developed a comprehensive framework for assessing the quality of mutually coupled arrays in terms of their radiation efficiency and diversity performance. The present paper summarises these ideas and attempts to convey additional insights into mutual coupling. A final example of a manufactured circular four-port array with a radiator separation of one tenth of the wavelength and with decoupling and matching network demonstrates the usefulness of our approach.