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Monday, November 4

Monday, November 4 9:20 - 10:30

MO1: Plenary Keynote Presentations 1

Rooms: Grand A, Grand B, Grand C

9:20 ***Lifelong Learning in Nature and Machines...N/A***

Hava Siegelmann (DARPA, USA)

A summary of ongoing work at DARPA under the direction of DARPA Program Manager Dr. Hava Siegelmann. This talk covers her Lifelong Learning Machines (L2M) and Guaranteeing AI Robustness against Deception (GARD) programs, plus ongoing work from her university research at the Univ. of Massachusetts, Amherst.

9:55 ***Wireless Beyond 100 GHz: Opportunities and Challenges for 6G and Beyond...N/A***

Theodore Rappaport (New York University & NYU WIRELESS, USA)

With the rollout of 5G millimeter wave mobile networks commencing around the globe, engineers and consumers are just now learning the benefits and pitfalls of massively broadband wireless connectivity. This talk demonstrates how today's early experiences are laying the foundations for revolutionary new products and services that will evolve over the next decade, and which will eventually be a part of 6G networks and beyond.

Monday, November 4 11:00 - 11:30

MO2A: Plenary Opening Session

Rooms: Grand A, Grand B, Grand C

Monday, November 4 11:30 - 12:40

MO2B: Plenary Keynote Presentations 2

Rooms: Grand A, Grand B, Grand C

11:30 ***Tumor Treating Fields (TTFields) from Theory to Clinical Practice...N/A***

Yoram Palti (NovoCure, Israel)

Keynote

12:05 ***Wireless Power Beaming - the Future is Now...N/A***

Avi Bar Cohen (Raytheon, USA)

Although Nikola Tesla conceived of wireless power transmission more than 100 years ago, applications of this mode of directed energy have lagged behind the use of focused RF beams for telecommunications and RADAR. W.C. "Bill" Brown's (Raytheon) invention of the rectifying antenna ('65) and demonstration of 34 kW in beamed power ('75) established the feasibility of wireless power beaming, but many challenges remain in extending the range, power level, operational frequencies, and rectenna technologies to provide wireless delivery of continuous power, at levels of MW to GW, over extended periods. Such wireless power beaming(WPB) can play a critical role in delivering renewable power from uninhabited regions to the earth's population centers, in extending the electrification of manned and unmanned airborne, ground, and naval vehicles with power delivered from remotely-located transmitters, and may well be a key enabling technology for powering space platforms, space exploration vehicles, and future space colonies, as well as delivering solar power from space to the power grid on earth and to remote off-grid locations. This Keynote presentation will open with a review of Tesla's and Brown's pioneering work and continue with the history of WPB-based Solar Power Satellite efforts, as well as other potential terrestrial and space applications. Attention will then turn to the key components of a notional WPB system - operating in RF, mmW, or laser frequencies - and the advances required to mature WPB as a pivotal application of Directed Energy technology.

Monday, November 4 14:00 - 15:50

CS1: Enhanced Communications Technologies for Future Networks

Room: Grand A

Chair: Theodore Rappaport (New York University & NYU WIRELESS, USA)

14:00 ***Maximal Entropy Reduction Algorithm for SAR ADC Clock Compression...1***

Arkady Molev-Shteiman and Xiao-Feng Qi (Futurewei Technologies, Inc., USA)

Reduction of comparison cycles leads to power savings of a successive-approximation-register (SAR) analog-to-digital converter (ADC). We establish that the lowest average number of comparison cycles of a SAR ADC approaches the entropy of the ADC output, and proposed a simple adaptive algorithm that approaches this lower bound. Today's SAR ADC uses binary search, which consumes more power than necessary for non-uniform input distributions commonly found in practice. We refer to a SAR ADC employing such a search algorithm the maximal entropy reduction ADC (MER ADC).

14:20 ***Interference-Free Space-Time Block Codes with Directional Beamforming for Future Networks...7***

Kelvin Anoh (University of Bolton, United Kingdom (Great Britain)); Bamidele Adebisi (Manchester Metropolitan University, United Kingdom (Great Britain)); Sumaila Mahama (University of York, United Kingdom (Great Britain)); Andrew Gibson (Manchester Metropolitan University, United Kingdom (Great Britain)); Haris Gacanin (Nokia Bell Labs, Belgium)

As the evolving communication standards would leverage on high data rates and low power consumption, future communication systems must be able to demonstrate these strengths. Space-time block codes (STBC) and quasi-orthogonal STBC (QO-STBC) including beamforming are multiple-input multiple output (MIMO) system design techniques used to improve data rates and reduce bit error ratio (BER). STBCs for larger antenna configurations use QO-STBC schemes which suffer from self-interference problems. The self-interference in QO-STBC systems diminish the data rates and worsen the BER. In this study, we present three (3) methods of overcoming the self-interference problems in QO-STBC systems. We implement the interference-free QO-STBC systems with directional beamforming to improve the data rates and also reduce the BER. The results show significantly improved BER performance when the interferences are eliminated. An additional 3dB gain is achieved at 10^-4 BER when the interference-free QO-STBCs are operated with directional beamforming. In terms of data rates, up to 6 bits/s at reasonably low power consumption are realized when the Hadamard-based QO-STBC is operated with directional beamforming.

14:40 ***A Direct-Conversion Digital Beamforming Array Receiver with 800 MHz Bandwidth/Channel at 28 GHz using Xilinx RF SoC...13***

Sravan Pulipati, Viduneth Ariyarathna, Udara Silva, Najath Mohomed Akram, Elias A. Alwan and Arjuna Madanayake (Florida International University, USA); Soumyajit Mandal (Case Western Reserve University, USA); Theodore Rappaport (New York University & NYU WIRELESS, USA)

This paper discusses early results associated with a fully-digital direct-conversion array receiver at 28 GHz. The proposed receiver makes use of commercial off-the-shelf (COTS) electronics, including the receiver chain. The design consists of a custom 28 GHz patch antenna sub-array providing gain in the elevation plane, with azimuthal plane beamforming provided by real-time digital signal processing (DSP) algorithms running on a Xilinx Radio Frequency System on Chip (RF SoC). The proposed array receiver employs element-wise fully-digital array processing supporting up to 1 GHz of operating bandwidth per antenna in digital. The ADC sample rate can be up to 2 GS/second. The RF mixed-signal data conversion circuits and DSP algorithms are operating on a single-chip RF SoC solution installed on the Xilinx ZCU1275 prototyping platform.

DC1: Circuits and Systems for Communication

Room: Grand B

Chair: Aleksey Dyskin (Technion - Israel Institute of Technology, Israel)

14:00 ***High System Gain E-Band Link in a Wideband Aircraft-to-Ground Data Transmission...18***

Ingmar Kallfass (University of Stuttgart, Germany)

A wireless communication link operating in E-band at 71-76 GHz with 30 dBm of transmit power from a GaN-based solid-state power amplifier and a 3-dB noise figure of its GaAs-based receiver is employed in a data transmission with up to 9.8 Gbit/s data rate between a plane and a ground station. Flying at a height of 1000 m above ground and at distances between 5 and 12 km from the receiver, a microlight aircraft hosts the payload mounted to its wing. The highly directional link is formed by a 39.7 dBi gain Cassegrain parabolic antenna in the plane-mounted transmitter, and a 48.7 dBi Cassegrain antenna with GPS-based antenna tracking in the ground terminal. Stable data links were established with up to 9.8 Gbit/s data rate employing QPSK, 8-PSK and 16-QAM modulation.

14:30 ***Pre-PA Delay-Line Based FIR Filter for Self-Interference Cancellation in Full Duplex Wireless Systems...23***

Nimrod Ginzberg (Technion, Israel); Dror Regev (Toga Networks A Huawei Company, Israel); Emanuel Cohen (Technion Institute of Technology, Israel)

In this paper we propose a pre-PA self-interference (SIC) cancellation FIR filter design approach implemented in a quadrature balanced PAs (QBPA) transmitter (TX) for full duplex wireless applications. Pre-PA SIC filter allows for flexible and efficient equalization of the cancellation signal by reusing the TX path, thus eliminating the need to couple TX power and facilitating linearization operations on both the TX and SIC signals. The paper discusses the trade-off between the implementation and calibration complexity of the filter and the TX-RX isolation bandwidth it provides, along with a quantitative comparison to post-PA SIC filter approaches, validated using system level simulations of behavioral full duplex transmitters.

14:50 ***Analysis and Design of an Asymmetric Doherty Power Amplifier at 2.6 GHz using GaAs pHEMTs...26***

Valentin Grams, Andres Seidel and Paul Stärke (Technische Universität Dresden, Germany); Jens Wagner (Technische Universität Dresden & Chair for Circuit Design and Network Theory, Germany); Frank Ellinger (Technische Universität Dresden, Germany)

This work presents an analytical guideline for the design of N-way Doherty power amplifiers operating at an output back-off (OBO) larger than 6 dB. Using this concept, an asymmetric Doherty power amplifier (ADPA) is designed for efficient transmission of signals with a high peak to average power ratio (PAPR) of 8.5 dB. Both the main and peak amplifier consist of the discrete GaAs pHEMT TGF2025 from Qorvo. The ADPA achieves an output power of 28.5 dBm with a power added efficiency (PAE) of 56.0 % at 2.6 GHz. At the back-off power (BOP) of 20.0 dBm, the PAE reaches its first local maximum which is equal to 50.0 %. The bandwidth of the circuit corresponding to a power gain reduction of 1 dB is 200 MHz.

15:10 ***Optimisation of a Doherty power amplifier based on dual-input characterisation...29***

Anna Piacibello (University of Roma Tor Vergata, Italy); Roberto Quaglia (Cardiff University, United Kingdom (Great Britain)); Vittorio Camarchia, Chiara Ramella and Marco Pirola (Politecnico di Torino, Italy)

The success of the Doherty architecture compared to other efficiency enhancement techniques derives mainly from its simple design and full-RF nature, not requiring complex digital signal processing to achieve high back-off efficiency. In this work we propose a design strategy for the optimisation of a Doherty power amplifier to mitigate the typical practical issues of this architecture related to inaccuracy of the non-linear model and of the manufacturing. The approach is based on the experimental characterisation of a dual-input Doherty prototype without input section. This test structure is obtained from a single-input Doherty amplifier, designed only through non-linear simulations, by removing the input section and allowing for separate control of the two RF inputs. From the collected data, approximated functions for the phase shift and power splitting versus frequency are identified to be realizable in hardware with RF networks. Compared to the reference single-input Doherty stage, a significantly improved behavior is registered in terms of output power (up to 2.7 dB), efficiency at saturation and back-off (30% and 15% respectively) and power gain (2 dB).

15:30 ***A Dual-Gate Downconverter for H-Band Employing an Active Load...34***

Christopher Grötsch (University of Stuttgart, Germany); Sandrine Wagner and Laurenz John (Fraunhofer IAF, Germany); Ingmar Kallfass (University of Stuttgart, Germany)

A single-ended active dual-gate zero-IF frequency downconverter for H-band applications is presented. The mixer is designed for a 240 GHz LO frequency and shows a flat conversion gain curve of -7 dB over a 3-dB bandwidth of more than 50 GHz from 220 to 270 GHz at a low LO power of -2 dBm. To reduce the DC power consumption an active load was integrated. The MMIC was realized in a 35nm gate-length InGaAs-based metamorphic HEMT technology.

SR1: Phased Array and Multistatic Radar Systems

Room: Grand C

Chair: Markus Gardill (InnoSenT GmbH, Germany)

14:00 ***Multistatic MIMO OFDM Radar for Drone Detection...N/A***

Mario Pauli (Karlsruhe Institute of Technology, Germany)

OFDM signals are well suited for passive and active multistatic radar systems due to their constant carrier frequency and thus relaxed efforts for frequency synchronization in comparison to FMCW based signals. Furthermore, frequency and time shifts can be corrected to a certain degree during signal processing. Active multistatic radar systems additionally offer the

advantage that the transmit signal and the position of the transmitter are known and can be arbitrarily controlled. In combination with MIMO such systems could be used to detect small objects with a highly angular dependent radar cross section like drones as well as to relax the demands for decoupling of transmitters and receivers.

14:30 ***Meteorological Phased Array Radar Research at NOAA's National Severe Storms Laboratory...39***

Mark Weber (NOAA OAR National Severe Storms Laboratory, USA)

The National Oceanic and Atmospheric Administration (NOAA) has pioneered the development and application of high-performance meteorological radar for public weather warning and forecasting services. The current operational system, the dual-polarization WSR-88D weather surveillance radar, has led to significant capability enhancements, for example, increased accuracy and lead time for severe weather and flash flood warnings. This paper describes research to determine whether the eventual replacement for the WSR-88D should exploit phased array radar (PAR) technology. Key severe weather warning service benefits for the rapid, adaptive scanning so enabled have been identified. PAR may also facilitate observations of winds and humidity in precipitation-free volumes by using high average-power pulse transmissions and adaptively scheduled, long duration dwells. Our research program is validating these operational benefits and maturing the associated data processing and numerical weather prediction (NWP) model assimilation techniques. In parallel, the engineering challenges associated with meteorological PAR are being addressed through hardware demonstration and data analysis. As an example, the Advanced Technology Demonstrator (ATD) - a 4 m diameter, S-band, dual polarization PAR - has recently been deployed at the National Severe Storms Laboratory. In 2020-2022 data collection, analysis and demonstration using the ATD will determine whether PAR can meet NWS requirements for quality of observations, while increasing the overall temporal sampling rate and adaptively concentrating observations in volumes of high importance. Two key determinations will be the effectiveness of PAR dual-polarization calibration techniques, and the efficacy of radar resource management techniques tailored to achieve the desired rapid scanning.

15:00 ***Novel approaches to expand detection coverage of fixed Unattended Ground Sensor systems...N/A***

Nino Srour (US Army Research Laboratory, USA)

Over the last few years, the Networked Sensing & Fusion Branch at the Army Research Laboratory has conducted research to advance the technology of Unattended Ground Sensor (UGS) systems to provide situational awareness in support of the US military. This research led to the implementation of new, multi-modal sensors, advanced novel communication networks, data fusion algorithms and a compilation of user feedback regarding desired UGS features. Some of these desired features can now provide: (i) an ability to accurately localize and track personnel or vehicles, (ii) communication links that are resilient and provide Line-of-Sight (LOS) and beyond LOS data exfiltration, (iii) standardized data output for interoperability to ease integration with other sensor systems, and (iv) low Size Weight and Power (SWaP) features for longevity in harsh battlefield environments. The evaluation of such UGS systems has highlighted a gap in this technology associated with the limited detection range of fixed ground sensors. This briefing will address novel ideas to extend range coverage of fixed ground sensors in open and urban environments.

15:30 ***Array-Level Approach to Nonlinear Equalization...45***

Nicholas Peccarelli (Advanced Radar Research Center & University of Oklahoma, USA)

Low-cost digital arrays suffer from nonlinear distortion, in both the transmitters (Tx) and receivers (Rx), introducing nonlinear spurious products, compression, and memory effects. Many linearization techniques have been researched to mitigate nonlinear distortion, such as digital pre-distortion (DPD) for Tx and nonlinear equalization (NLEQ) for Rx. However, these linearization techniques have mostly focused on channel-level correction, ignoring the array-level aspects. This paper gives an overview of the array-level aspects that need to be taken into account to effectively use NLEQ for digital arrays. Furthermore, an averaging method is proposed to help reduce computational complexity of NLEQ techniques, while leveraging the previously discussed array-level advantages.

T1: Simulation-Based GaN PA Design: From Understanding Non-Linear Models to Complete PA Design Flows

Room 3

14:00 ***Simulation-Based GaN PA Design: From Understanding Non-Linear Models to Complete PA Design Flows...N/A***

Larry Dunleavy (Modelithics, USA)

Simulation-Based GaN PA Design: From Understanding Non-Linear Models to Complete PA Design Flows

CEM1: Special Session - Computational Electromagnetics Techniques for Nanoscale Modeling

Room 4

Chairs: Nikolaos L. Tsitsas (Aristotle University of Thessaloniki, Greece), Grigorios Zouros (National Technical University of Athens, Greece)

14:00 ***Terahertz Range Elementary Dipole Excitation of a Thin Dielectric Disk Sandwiched between Two Graphene Covers: Integral Equation Analysis...51***

Alexander I. Nosich (IRE NASU, Ukraine)

We study, using the integral equation technique, the scattering of the field radiated by an elementary dipole, by a thin dielectric disk sandwiched between two conformal graphene covers, on the top and bottom faces. To build a mathematical model of such scatterer, we use the generalized boundary condition in the form first obtained by Mitzner and Bleszynski et al. and generalized by Karlsson. This enables us to derive dual integral equations in the disk plane for the Hankel transforms of the tangential electric and magnetic field components, and cast it to a set of two coupled Fredholm second-kind integral equations. The latter equations are discretized and solved numerically with the guaranteed convergence. We compute and plot the power radiated by an elementary magnetic dipole placed above such a composite disk, in the THz range. The studied scatterer is a complicated open resonator supporting the plasmon and the dielectric-disk modes.

14:30 ***Bright and Dark Supermodes of Twin Dielectric Nanowire Photonic Molecule Excited by a Modulated Electron Beam...55***

Dariia O. Herasymova (Institute of Radio-Physics and Electronics NASU, Ukraine)

The optical diffraction radiation caused by a modulated beam of electrons moving between two identical circular dielectric nanowires, which form a photonic molecule, is studied. The electromagnetic field of such a beam is a slow wave, which decays exponentially from the beam trajectory. It is scattered by the nearby objects and hence depends on their shape, material, and location. We reduce the wave-scattering problem to the discrete form using the Fourier expansions in local polar coordinates of each wire and the addition theorems for the cylindrical functions. To provide mathematically guaranteed convergence, we cast the derived matrix equation to the Fredholm second-kind type. Photonic molecule is an optical open resonator, which supports supermodes of four orthogonal symmetry classes. The diffraction radiation power displays the peaks at the supermode wavelengths, some of which appear only if the beam trajectory is shifted from the central (i.e. symmetric) position.

14:50 ***Scattering by an all-dielectric metasurface including a periodic arrangement of arbitrary scatterers...59***

Dimitrios K. Gerontitis and Nikolaos L. Tsitsas (Aristotle University of Thessaloniki, Greece)

An all-dielectric metasurface containing a periodic arrangement of dielectric scatterers is considered. The problem of plane-wave scattering by this metasurface is analyzed by developing and employing a rigorous entire-domain integral-equation methodology. This methodology is fast and accurate and can aid relevant optimizations of the associated parameters. Numerical

results are reported for the variations of the reflection and transmission coefficients.

15:10 ***Highly-directive systems inspired by physical bounds on scattering processes...63***

Iñigo Liberal (Public University of Navarre, Spain)

The identification of physical bounds of performance is central to the understanding of light-matter interactions and the design of optimal devices that reach those theoretical limits. Here, we extend our previous work to derive physical bounds of performance for time-harmonic scattering processes, including total scattering, total absorption, bistatic scattering and minimal scattering sensors, for arbitrary far-field illumination of a system in the presence of a material interface. The derived upper bounds emphasize a weighted function of the scattering directivity as the main limiting factor in the theoretically achievable performance for all aforementioned scattering processes. Therefore, our analysis remarks the potential benefits of using highly-directive systems in multiple configurations.

15:30 ***A Technique for Nanoscale Modeling of Uniaxial Spheroids...66***

Georgios Kolezas and Grigorios Zouros (National Technical University of Athens, Greece); Gerasimos Pagiatakis (School of Pedagogical & Technological Education (ASPETE), Greece); John Roumeliotis (National Technical University of Athens, Greece)

In this work we develop a technique for nanoscale modeling of uniaxially anisotropic prolate spheroidal nanoantennas. To this end, we develop a formal series solution, valid for any aspect ratio of the spheroidal nanoantenna. To solve the problem, we follow a two-step procedure: first, spherical vector wave functions with discrete wavenumbers are used for the expansion of the fields in the domain of the anisotropic scatterer. Second, these spherical expansions are transformed to spheroidal ones, using suitable expansions relating the spherical vector wave functions with the spheroidal ones. Then, satisfying the boundary conditions at the spheroidal surface, we obtain infinite sets of nonhomogeneous equations from which, upon truncation, we may calculate the bistatic and the total scattering cross section. We sufficiently compare the cross sections obtained by the developed method, for different values of aspect ratio and anisotropy, with the discrete dipole approximation method. The magnetic and electric dipolar resonances are then investigated in the context of nanoantenna design.

STA: Short Course: Stand on the Antennas and Propagation Standards

Room 5

14:00 ***Stand on the Antennas and Propagation Standards...N/A***

Vikass Monebhurrun (SUPELEC, France); Lars Foged (Microwave Vision Italy, Italy); Vince Rodriguez (NSI-MI Technologies, LLC. & University of Mississippi, USA)

The IEEE Antennas and Propagation Standards Committee (AP-S/SC), sponsored by the IEEE Antennas and Propagation Society (AP-S), develops and maintains standards that are within the fields of antennas and propagation. The objective of the short course is to disseminate information about the standards developed for antennas, propagation and electromagnetics applications, and to encourage their use.

AP1: Special Session - Slotted Arrays 1

Room: Royal H

Chairs: Jacob Coetzee (Queensland University of Technology, Australia), Sembiam R. Rengarajan (California State University, USA)

14:00 ***Advances in Slotted Waveguide Array Antenna Technology...70***

Sembiam R. Rengarajan (California State University, USA)

We review the state of the art of slotted waveguide array antenna technology. Design and analysis techniques of slot arrays in standard rectangular waveguides are discussed first. Subsequently slots cut in ridge waveguides, iris excited waveguides, strip lines, radial waveguides and gap waveguides are addressed. Some applications of slot arrays and manufacturing techniques are also briefly reviewed..

14:30 ***Progress of Perpendicular-Corporate Feed for a Multi-Layer Parallel-Plate Slot Array Antenna...N/A***

Jiro Hirokawa, Hisanori Irie and Takashi Tomura (Tokyo Institute of Technology, Japan)

This paper reviews the progress of perpendicular-corporate feed for a multi-layer parallel-plate slot array antenna. The coupling apertures are fed by a corporate feed circuit and each of the coupling apertures excites 2x2 radiating slots with additional ones from the bottom to the top of the multi-layer parallel plates. Dielectric with proper permittivity is introduced between the coupling aperture layer and the radiating slot layer to excite a standing wave to prevent truncation effect of the finite array. The experimental results have been given. Unfortunately, air gaps among stacking thin expanded-dielectric sheets increases the reflection. Additional slot layers increase the reflection bandwidth and the pair-slot layer suppresses the sidelobes in the 45-degree plane by simulations. This paper is submitted to the special session organized by Prof. Sembiam Rengarajan.

14:50 ***Overview of RLSA Antenna Design and Optimization Techniques developed at the University of Siena...75***

Santi Concetto Pavone (Università degli Studi di Catania, Italy); Matteo Albani (University of Siena, Italy)

In this paper, we present an overview of radial line slot array (RLSA) antenna design and optimization techniques developed in the past years at the University of Siena, both for near and far field applications at microwaves/millimeter waves. Moreover, also the possibility of generating localized pulses in time domain by means of RLSA is briefly sketched.

15:10 ***Compensation for Asymmetrical Slot Fields in the Design of SIW Slot Arrays...78***

Soumya Sheel (Queensland University of Technology, Australia)

For high-frequency applications, slot arrays are often implemented in Substrate Integrated Waveguide (SIW). Apart from retaining high performance attributes of metallic slotted waveguide antennas, the manufacturing process for SIW slot arrays is simple and cost-effective. Although the viability of slot arrays in SIW has been widely reported, high-precision design of arrays to stringent specifications is limited. For shaped beam or low side-lobe patterns, strict control over element excitation of each slot is vital. Conventional design principles fall short in this regard, largely due to failure of the simplified equivalent circuit for slots that does not account for the asymmetry in the slot field distribution. In this paper, we present an improved design technique that accommodates asymmetry in slot fields and incorporates the full T-network equivalent circuit for each slot.

RA1: Special Session - Antennas in Radio Astronomy

Room: Royal I

Chairs: Vladimir Khaikin (The Special Astrophysical Observatory, RAS, Russia), Di Li (National Astronomical Observatories, Chinese Academy of Sciences, China)

14:00 ***From ALMA to Super-ALMA...82***

Gianpietro Marchiori, Francesco Rampini, Massimiliano Tordi, Matteo Spinola and Riccardo Bressan (EIE Group Srl, Italy)

A roadmap for the development of THz astronomical observatories is presented, starting from the experience gained during the design and construction of the European antennas for the Atacama Large Millimetre Array. The proposed developments are outlined from the engineering point of view, in order to provide to the scientific community some clues about the technology state-of-the-art. Such information could possibly help scientists to define the science case and the development roadmaps for future THz observatories, taking into account the current status of the technology.

14:30 ***FAST A+: A Cost Effective Plan for Expanding FAST...88***

Di Li (National Astronomical Observatories, Chinese Academy of Sciences, China); Ran Duan (NAOC, China)

The Five-hundred-meter Aperture Spherical radio Telescope (FAST) produced its first light in September 2016. Now it is near the end of its commissioning phase. In L-band, the measured gain of FAST has reached above 2000 m2/K, two times that of Arecibo, making FAST the most sensitive antenna in history, by far. During commissioning, a slew of early science projects were carried out, resulting in more than 100 pulsar discoveries, including millisecond ones, binary systems, pulsars in globular clusters (both with previous known sources and without), and sources with a plethora of interesting emission phenomena. The first 'shared-risk' open call for proposal has been released in February, 2019, receiving more than 130 proposals from 21 PI institutions. The winning projects, with topics covering cosmology, gravitational wave, galaxies, interstellar medium, pulsars, etc., are being carried out. A special volume quantifying the science outlooks in multiple frontiers of radio astronomy was published in the journal Astronomy and Astrophysics. The first batch of early science results have been published in a special issue of the journal Science China Physics, Mechanics & Astronomy. We now expect to transit into normal operation before the end of 2019.

14:50 ***Astronomical Technologies and Satellite Communications...92***

Massimiliano Tordi, Gianpietro Marchiori, Gianpietro De Lorenzi and Francesco Rampini (EIE Group Srl, Italy); Rosario Cimmino (EIE Group Srl, USA); Matteo Spinola (EIE Group Srl, Italy)

Satellite communication infrastructures and radio-telescopes have always shared several technological elements. There are several examples in the history of radio-astronomy where dismissed Earth Stations have been converted into radio-telescopes. Dual use stations are also an example, while on some cases satellite communications took advantage of technologies developed for radio-astronomy to improve their capabilities. Future scenarios may see a deeper integration between the two infrastructures: a specific example is discussed with reference to the Square Kilometer Array.

15:10 ***The Suffa project and high capacity channels for deep space communications systems incorporating cryogenic elements...98***

Vyacheslav Vdovin (Nizhniy Novgorod State Technical University & IAP RAS, Russia); Yurii Artemenko (Lebedev Physical Institute RAS, USA)

The problem of long-range space communications systems with high-capacity channels is topical due to a series of deep space projects being currently implemented, such as international missions Exo-Mars and Millimetron. To maximize the rate of the data transfer in space communications systems, antennas with maximum available dimensions are used to provide reasonable capacity. We are offering an approach to increase the capacity of data transfer channels by use of a combination of a large antenna and wide-bandwidth, high-capacity, low-noise, high-frequency cryogenic receivers. When the communication is performed in the millimeter waveband the atmospheric propagation becomes the essential limiting factor to the use of the channel. The theoretical estimations of capacity limits under different atmospheric conditions for diverse hardware and the results of experiments are presented.

15:30 ***Simulation and Analysis of Radiation Pattern of Multi-Reflector Radio Telescope Using the MLPO Algorithm...N/A***

Michael Lebedev and Vladimir Khaikin (The Special Astrophysical Observatory, RAS, Russia); Christine Letrou (TELECOM SudParis, France); Amir Boag (Tel Aviv University, Israel)

In this presentation, we report the results of RATAN-600 radiation pattern calculations in two polarizations using both the conventional approach combining geometrical optics aperture field computation with Fourier transform accelerated far-field computation and the fast multilevel physical optics technique. The results of radiation pattern measurements in an auto-collimation mode are also reported. Measuring two-dimensional radiation patterns of the radio telescope using a geostationary satellite as a remote source of microwave radiation is also a matter of great interest, in particular towards verification of the numerical simulation methods. Examples of such measurements are presented as well.

SP1: Signal Processing & Imaging 1

Room: Royal J

Chair: Arie Yeredor (Tel-Aviv University, Israel)

14:00 ***Cyber Attacks on Internet of Things Sensor Systems for Inference...N/A***

Rick Blum (Lehigh University, USA)

The Internet of Things (IoT) improves pervasive sensing and control capabilities via the aid of modern digitial communication, signal processing and massive deployment of sensors. The employment of low-cost and spatially distributed IoT sensor nodes with limited hardware and battery power, along with the low required latency to avoid unstable control loops, presents severe security challenges. Attackers can modify the data entering or communicated from the IoT sensors which can have serious impact on any algorithm using this data for inference. In this talk we describe how to provide tight bounds (with sufficient data) on the performance of the best algorithms trying to estimate a parameter from the attacked data and communications under any assumed statistical model describing how the sensor data depends on the parameter before attack. The results hold regardless of the estimation algorithm adopted which could employ deep learning, machine learning, statistical signal processing or any other approach. Example algorithms that achieve performance close to these bounds are illustrated. Attacks that make the attacked data useless for reducing these bounds are also described. These attacks provide a guaranteed attack performance in terms of the bounds regardless of the algorithms the estimation system employs. References are supplied which provide various extensions to all the specific results presented and a brief discussion of applications to IEEE 1588 for clock synchronization is provided.

14:30 ***Multi-level Off grid DOA estimation of sparse arrays Using OMP algorithm...101***

Neela Pavani, Swathi Vakkalagadda and Pushyami Padidam (National Institute of Technology, Andhra Pradesh, India); Kishore Kumar Puli (National Institute of Technology Andhra Pradesh, India)

Direction Of Arrival (DOA) estimation plays a major role in the operation of smart antennas. It has been a research area in array signal processing since decades. Although there are many algorithms to solve this problem, each algorithm has its own advantages and disadvantages. Recently, Compressive Sensing (CS) technique revolutionised the idea of sampling in signal processing. We can have sparse representation of DOA problem using angular grid model and hence CS techniques can be used to solve for DOA's. Using the idea of CS, even one snapshot is sufficient to estimate the angles. Orthogonal Matching Pursuit (OMP), one of the algorithm in the class of greedy algorithms is used in this paper for DOA estimation. The simulations using this algorithm for uniform linear array and sparse array shows the performance of the algorithm. Also off grid model is employed to find DOA of sources that are impinging in grid spaces i.e., between grid points.

14:50 ***Advanced Real-Time Strategies for Direction Finding in Rapidly Changing Scenario...106***

Paolo Rocca (University of Trento, Italy); Mohammad Hannan (ELEDIA Research Center, University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy)

Recent advances on real-time direction finding strategies based on Bayesian Compressive Sensing (BCS) are discussed here. The open-circuit voltages measured at any instant of time (single snapshot data) are processed by the single-task and the multi-task Bayesian Compressive Sensing (ST-BCS and MT-BCS), combined with single frequency and multi-frequency approaches, respectively. In particular, the STBCS is integrated within an iterative multi-scaling strategy (IMSA-BCS) for narrowband signals and the MT-BCS is extended to the multi-frequency BCS (MF-BCS) for wideband signals. The selected results from extensive analysis highlight that the proposed approaches estimate the DoAs with high accuracy in a fraction of second.

15:10 ***Estimation of the Channel and I/Q Imbalances with ZCZ Sequences and Superimposed Training...110***

Israel Alejandro Arriaga-Trejo (Consejo Nacional de Ciencia y Tecnología & Autonomous University of Zacatecas, Mexico)

In this paper, the use of superimposed training (ST) and zero-correlation-zone (ZCZ) sequences is considered to estimate the joint effects of the channel response and radio-frequency (RF) impairments in the analogue-front-end (AFE) of the transmit and receiving terminals in a communications system. The RF impairments assumed are in-phase and quadrature-phase (I/Q) imbalances as well as local oscillator (LO) leakages. The analysis shows that zero mean ZCZ sequences with good periodic auto-correlation and good periodic complementary auto-correlation properties are adequate to decouple the variables of interest at the receiver. The performance of the technique is evaluated analytically and through numerical examples.

15:30 ***Mode Selection of Wideband Acoustic Signals Using Time-Frequency (Warping) Analysis for Single Hydrophone. Comparison with Array Filtering in Variable Medium...116***

Boris Katsnelson (University of Haifa, Israel)

Broadband air-gun data from SWARM'95 experiment in shallow water area of Atlantic shelf are used to analyze mode filtering using time-frequency analysis in the form of Warping Transform. Sound fluctuations in the presence of nonlinear internal waves are considered using this analysis. Results are compared with mode filtering using vertical line array (VLA). It is shown that Warping Transform allows us to provide mode filtering in shallow water environment, changing in time and space in the presence of moving nonlinear internal waves by single hydrophone only. Temporal variations of mode composition in given case have properties specific for manifestation of horizontal refraction in the form of focusing/defocusing in horizontal plane.

Monday, November 4 16:10 - 18:00

CS2: Future Communications Technologies & Developments Directed to Industry

Harvey Freeman

Room: Grand A

Chair: Steve Weinstein (CTTC Group, USA)

16:10 ***Future Technologies and Developments Directed to Industry...N/A***

Harvey Freeman (HAF Consulting, Inc., USA)

The Panelists in this session will discuss Fog/Cloud, 5G and Beyond, Radio Wave Imaging, and Public Safety Communications Technologies. Advantages, opportunities, privacy, security issues, and other technology aspects will be touched on in these topics.

DC2: Integrated Sensors for Radar/Lidar Applications

Room: Grand B

Chair: Ingmar Kallfass (University of Stuttgart, Germany)

16:10 ***UWB Radar for High Resolution Breast Cancer Scanning: System, Architectures, and Challenges...120***

Matteo Bassi and Daniel Oloumi (Infineon Technologies AG, Villach, Austria); Andrea Bevilacqua (University of Padova, Italy)

With ever increasing of breast cancer, the need for diagnosis and monitoring tools, i.e., radiotherapy or chemotherapy, is felt more and more. In addition to the available clinical methods, i.e. MRI, CT scan and Mammography, it is required to develop new tools with inexpensive and portable components to increase the accessibility and reducing the queue time. Radar sensing and imagining is new and emerging technology to be enabled for biomedical applications. Ultra-wideband has raised considerable interest due to its high resolution. UWB radar can be realized in different technologies, discrete or integrated. The miniaturization carried of the integrated system allows envisioning an antenna array made of modules in which each compact or planar antenna is directly assembled with the radar transceiver chip. A customized integrated circuit can be tailored to fulfill the requirements, i.e., operational bandwidth, dynamic ranges, etc. In this talk, we investigate the typical system and circuit-level challenges.

16:40 ***Two quantum effects applied to optical imaging...N/A***

Radek Lapkiewicz (University of Warsaw, Poland)

Quantum imaging typically involves illumination of a sample with light prepared in a quantum state and subsequent detection of light scattered by the sample. We review two classes of quantum imaging experiments which do not follow this route. In the first class, quantum properties of light emitted by the sample itself are used. In the second class, the light scattered by the sample is not detected at all. Each of the discussed experiments is based upon one of two quantum optical phenomena, namely photon antibunching or induced coherence without induced emission.

17:00 ***A Highly-Integrated 60 GHz Receiver for Radar Applications in 28 nm Bulk CMOS...124***

Radu Ciocoveanu (Infineon Technologies AG / Friedrich-Alexander University Erlangen-Nuremberg (FAU), Germany); Robert Weigel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Vadim Issakov (Infineon Technologies AG, Germany)

This paper presents a low-power highly-integrated 57-64 GHz receiver for short range frequency-modulated continuous-wave (FMCW) radar applications and fabricated in a 28nm CMOS technology. Measurement results show that the receiver(Rx) achieves a 18.9 dB conversion gain (CG) with a −12dBm input referred 1-dB compression point (IP1dB) at 60 GHz. A 7.6 dB double sideband noise figure (NFdsb) is achieved at 10MHz offset. Furthermore, the circuit draws 44mA from a single 0.9V supply and the chip core size is 0.58mm x 0.33 mm.

17:20 ***mm-wave and UWB CMOS 65nm SoC for radar applications...129***

Nadav Mazor and Naftali Chayat (Vayyar, Israel)

A System on Chip (SoC) solution for ultra-wideband (UWB) and mm-wave MIMO radar applications is presented. The RFIC is implemented in a standard CMOS 65 nm process, comprising 24 transmit-receive modules for UWB along with 48 transmit-receive modules for mm-wave frequencies. Targeting radar applications, the signal generation architecture supports a variety of waveforms. The receive side includes multichannel digitization, memories and DSP processor for radar signal processing. The SoC family has several variants, supporting the 76-81 GHz band for automotive industry and a 57-71 GHz band for smart home applications. The die area is 83 mm2 and it is packaged in a flip-chip BGA package.

17:40 ***Monolithic 3D-LiDAR Architecture Based on CMOS Silicon-Photomultiplier (SiPM)...N/A***

Ayal Eshkoli (Technion, Israel); Yael Nemirovsky (Technion_Israel institute of Technology, Israel); Amikam Nemirovsky (Technion, Israel)

This paper focuses on the system architectures of LiDAR based on CMOS Silicon Photomultiplier (SiPM) - a novel solid-state sensor that is closely related to SPADs (single photon avalanche diode in Geiger Mode) as the building block for innovative LiDARs. The simplest description of the SPAD is a binary photon-activated "switch" that counts digitally single photons, at a sampling time interval determined by its dead-time (approximately 20 nsec). SPAD sensors are the most sensitive silicon based solid state optical sensors. However, during recovery,

the SPAD cannot detect other photons. Hence, arrays of CMOS-SPAD Geiger mode sub-pixels, which are electrically combined in parallel and are known as CMOS Silicon Photomultiplier (SiPM), overcome this limita¬tion, enabling photon-counting as well as photon-timing. The CMOS SiPM readout circuitry requires advanced mixed signal design, where digital signals are combined analogically and the timing of these signals are then measured digitally.

SR2: Radar Systems and Applications I

Room: Grand C

Chair: Mario Pauli (Karlsruhe Institute of Technology, Germany)

16:10 ***Present state and future trends in automotive radar...N/A***

Rudolf Lachner (Rudolf Lachner Consulting, Germany)

The talk gives an overview of present commercial automotive radars in the 76-81 GHz range. These radars are adequate to support ADAS applications up to a level 2 of autonomous driving. Higher automated driving levels of 3 and beyond impose very challenging requirements on reliable environmental sensing. Current development activities to achieve these requirements with radar will be presented as well.

16:40 ***Signal Analysis and Radar Cooperation using Automotive Radar System Architectures...N/A***

Markus Gardill (InnoSenT GmbH, Germany)

Today's automotive radar architectures are to a large extent software defined: a modern radar frontend typically is a fully integrated MMIC providing all necessary hardware subsystems such as multiple TX and RX channels, synthesizers, timing & control engines, data converters and high speed streaming interfaces to provide CW, FMCW and Chirp-Sequence Radar functionality. Additional hardware subsystems such as phase shifters and TX switches provide further modulation degrees of freedom, necessary e.g. for coherent MIMO operation. The overall operating state of the radar is then defined by the configuration of the MMIC with all of its mentioned resources, which easily may requires up to one thousand registers to be set. And since those settings are controlled by the software running on the signal processor of the radar, the radar truly can be regarded as a software defined system. For future radar systems, besides taking radar measurements in the traditional sense, handling of radar interference and passive/cooperative radar gains more and more attraction. Current research work typically addresses those challenges by implementing novel ideas and methods on high-performance radar test beds e.g. using FPGAs and full-band receivers. In this presentation it will be shown how the software defined nature of today's commercial automotive radar systems can be used to implement additional functionality such as spectral analysis and passive/cooperative radar on commercially available radar sensors by just modifying its software configuration.

17:10 ***Recent Advances in Joint Radar-Communications Processing...N/A***

Kumar Vijay Mishra (The University of Iowa, USA)

Synergistic design of communications and radar systems with common spectral and hardware resources is defining a new era toward efficient utilization of radio-frequency spectrum. This joint radar-communications (JRC) model has advantages of low cost, compact size, less power consumption, resource sharing, and safety. Today, the JRC at the higher end of the RF spectrum, i.e., the millimeter wave (mm-Wave), is attracting significant research interest because of emerging cutting-edge radar and communications applications in this band. Major challenges in realizing mm-Wave JRC are joint waveform design and performance criteria that would optimally trade off between communications and radar functionalities. This talk will give an overview of advances in JRC with an emphasis on mmWave.

17:40 ***Ambiguity Function Based Radar Waveform Classification and Unsupervised Adaptation Using Deep CNN Models...132***

Pavel Itkin and Nadav Levanon (Tel Aviv University, Israel)

We present a robust generalized approach to phase and frequency modulated LPI Radar waveform classification and adaptation, inspired by deep convolutional neural architectures. We use a complex Ambiguity Function matrix as a pre-processing step, following which, a waveform classification, or adaptation to unlabeled reference target domains, is performed. We test our method on a wide range of tasks, datasets, and different signal distributions. Our method surpasses the state-of-the-art performance on classification problems on multi-encoding, multi-feature datasets, in diverse and difficult conditions. Our novel approach to an unlabeled Radar waveform adaptation reveals impressive classification improvements to domain shifted unlabeled signals.

T2: Wireless Powering - from Harvesting µW/cm2 to kW Capacitive Powering for Vehicles

Room 3

16:10 ***Wireless powering- from harvesting µW/cm2 to kW capacitive powering for vehicles...N/A***

Zoya Popović (University of Colorado at Boulder, USA)

Wireless powering- from harvesting µW/cm2 to kW capacitive powering for vehicles

CEM2: Computational Electromagnetics 2

Room 4

Chairs: Ozgur Ergul (Middle East Technical University, Turkey), Roberto D Graglia (Politecnico di Torino, Italy)

16:10 ***High-Order Modeling for Computational Electromagnetics...N/A***

Roberto D Graglia (Politecnico di Torino, Italy)

This presentation provides an overview of the last decade advances in computational electromagnetics concerning the development and use of high-order models for Moment Method and Finite Element Method applications. Various two- and three-dimensional high-order divergence- and curl-conforming vector bases used for the solution of differential and integral equations are compared and considered before presenting basis functions of either substitutive or additive kind able to model vertex, edge, and corner singularities. The implementation problems and the advantages provided by use of these higher-order models are discussed in detail thereby presenting several results.

16:40 ***MFIE-Based Formulation Using Double-Layer Modeling for Perfectly Conducting Objects...138***

Sadri Guler, Hande Ibili and Ozgur Ergul (Middle East Technical University, Turkey)

We present resonance-free solutions of scattering problems involving closed conductors using the magnetic field integral equation (MFIE). In the literature, MFIE is often combined with the electric-field integral equation (EFIE) to avoid internal resonances that can significantly contaminate solutions especially when scatterers become electrically large. The resulting combined-field integral equation (CFIE), however, possesses the disadvantages of EFIE, e.g., ill-conditioning for dense discretizations. We show that placing an interacting inner surface inside the given object and enforcing internal fields to be zero can mitigate internal resonances, making MFIE resonance-free without employing EFIE. Using an arbitrary inner surface can significantly suppress internal fields; but, as also shown in this contribution, the size of the inner surface, i.e., the distance between inner and outer surfaces, can be critical to obtain accurate results that are comparable to those obtained with the conventional CFIE.

17:00 ***Comparison of Two Convergent Numerical Methods for Solving the Problem of Wave-Scattering by a Dielectric Rod with a Conformal Strip of Graphene...144***

Sergii V. Dukhopelnykov (Usikov Institute for Radiophysics and Electronics NASU & V. N. Karazin Kharkiv National University, Ukraine)

We consider the scattering of an H-polarized plane wave by an infinite circularly curved graphene strip of arbitrary angular width, placed at the dielectric rod. Our analysis is based on the two types of analytical methods. The first is a hypersingular integral equation for the current induced on the strip. Discretization of this equation is carried out by the Nystrom-type method that has a guaranteed convergence. The second is the method of analytical regularization (MAR), which uses explicit inversion of the static part of the problem. We perform numerical experiments demonstrating how the rate of convergence depends on truncation number and interpolation order. We compare these two methods and their errors as a function of frequency.

17:20 ***Combining Physical Optics and Method of Equivalent Currents to create unique near-field propagation and scattering technique for automotive radar applications...148***

Gregory Skidmore (Remcom, Inc., USA); Tarun K Chawla (Remcom, USA); Gary Bedrosian (Remcom, Inc., USA)

The scattering environment for automotive radar is challenging for modeling and simulation, generating backscatter returns not just from vehicles but also from structures and features within the immediate environment. Remcom's WaveFarer® is a simulation tool that combines ray-tracing algorithms with high-frequency asymptotic physics methods, with Physical Optics (PO) and the Method of Equivalent Currents (MEC) at its core, supplemented by Geometric Optics (GO) and the Uniform Theory of Diffraction (UTD) to handle multipath between structures. In this paper, WaveFarer is used to evaluate radar returns from vehicles in a typical road environment. Drive scenarios are constructed with the radar and vehicles in motion, along with stationary roadside clutter. Simulation results are post-processed to calculate additional quantities, such as the range-Doppler. The overall objective is to demonstrate the ability of simulations to characterize radar scattering from vehicles and features along a road, at ranges and frequencies relevant for automotive radar.

17:40 ***Method of Analytical Regularization Based on the Static Part Inversion in the H-Wave Scattering by a PEC Strip Grating on Top of a Dielectric Substrate...154***

Fedir Yevtushenko (Institute of Radio-Physics and Electronics NASU, Ukraine); Sergii V. Dukhopelnykov (Usikov Institute for Radiophysics and Electronics NASU & V. N. Karazin Kharkiv National University, Ukraine)

Considered is the plane H-polarized wave scattering from an infinite flat grating of perfect electrically conducting strips, placed on the interface of a dielectric slab. We reduce this problem to a dual series equation for the complex amplitudes of the Floquet spatial harmonics. Then we perform analytical regularization of this equation, based on the inversion of the static part of the problem with the aid of the Riemann-Hilbert Problem. This yields a Fredholm second-kind infinite matrix equation, numerical solution of which has a guaranteed convergence. We perform numerical experiments demonstrating how the rate of convergence depends on the thickness and dielectric permittivity of the slab.

YP: Young Professionals in Automotive

Room 5

16:10 ***Opening remarks...N/A***

Aleksey Dyskin (Technion - Israel Institute of Technology, Israel)

Opening remarks

16:15 ***Our vision to autonomous driving...N/A***

Omer Keilaf (Innoviz Technologies, Israel)

Our vision to autonomous driving

16:45 ***Bringing the power of radar to autonomous driving...N/A***

Koby Morenko (Arbe Robotics, Israel)

Bringing the power of radar to autonomous driving

17:15 ***Invisible Light, Invisible Data: Leveraging SWIR to Solve the Visibility Challenge For ADAS and AV...N/A***

Avi Bakal (TriEye, Israel)

Invisible Light, Invisible Data: Leveraging SWIR to Solve the Visibility Challenge For ADAS and AV

AP2: Slotted Arrays 2

Room: Royal H

Chairs: Jacob Coetzee (Queensland University of Technology, Australia), Sembiam R. Rengarajan (California State University, USA)

16:10 ***A 1-D Steerable Beam Slotted Waveguide Antenna Employing Non-Conventional Aperiodic Array Architecture for mm-wave Line-Of-Sight MIMO...160***

Marianna Ivashina and Thomas Eriksson (Chalmers University of Technology, Sweden); Robert Rehammar (Bluetest AB & Chalmers University of Technology, Sweden); Shi Lei (China Academy of Space Technology, Sweden); Carlo Bencivenni (Gapwaves AB, Sweden); Rob Maaskant (CHALMERS, Sweden)

A 9 × 9 line-of-sight MIMO test setup is presented. The slotted waveguide (WG) antenna designed for this setup achieves low side-lobe levels (SLLs) in all planes for multiple scanned beams, while minimizing the loss in antenna efficiency and bandwidth limitations. The aperiodic arrangement of several parallel ridge WGs in the E-plane - each with a different number of equally-spaced and equally-excited radiating slots along the H-plane, and each possibly integrated with its own TX/Rx module - has been optimized through a Compressive Sensing approach. This results in 160 slots organized in 16 columns offering 29 dBi peak gain at a 27.5-31.5 GHz band with a ±10◦ scan range in the E-plane for the ETSI Class-II-compliant beams. The measurements of 12 identically beamformed antenna prototypes for the broadside beam confirm the expected high antenna efficiency (70-90%), and low input impedance mismatch over the entire operating bandwidth.

16:30 ***Overview of High Frequency Electronics Integration Concepts for Gap waveguide based High Gain Slot Antenna Array...164***

Ashraf Uz Zaman (Chalmers University of Technology, Sweden); Abbas Vosoogh (Metasum AB, Sweden); Jian Yang (Chalmers University of Technology, Sweden)

This paper presents an overview of different low-loss microstrip to waveguide transition designs suitable for integrating millimeter wave electronics to a gap waveguide based slot array. Typically, E-plane probe type of transitions are widely used at mmWave frequency range to couple RF signal from a TX/RX MMIC to the waveguide section. H-plane split-blocks are avoided due to leakage problem from tiny slits formed by imperfect metal connections. On the other hand, the traditional slot arrays are built using H-plane split blocks. This makes it very challenging to integrate electronics and other passive components such as diplexer filter directly to a high gain planar antenna array. To overcome this above mentioned problem, we

propose to use low-loss H-plane transitions to integrate RF electronics with the multi-layer gap waveguide based slot array. We demonstrate a completely packaged front-end at E-band showing the potential of the gap waveguide technology to build very compact full-duplex wireless system.

16:50 ***Method-of-Moment analysis of slender elliptic slots...168***

Giuseppe Mazzarella, Giorgio Montisci and Alessandro Fanti (University of Cagliari, Italy)

Waveguide slot arrays are still one of the most popular solutions for microwave and radar antennas. In addition to standard rectangular shunt slots, there is an increasing interest in non--rectangular slots, which can perform better is some applications. We present here a complete approach to the computation of the self--admittance of a single elliptic slot, which has a better power handling than rectangular slots and, when the eccentricity is close to one, also a low cross-polarization. The analysis is done in the spectral domain using the Method--of--Moments, and a new approach to the computation of the Fourier transform of the slot (equivalent) magnetic current is presented.

17:10 ***Gain Optimization Methods for SIW Leaky-Wave Antennas With Transverse Slots...173***

Thomas Vaupel (Fraunhofer FHR, Germany)

Substrate integrated waveguides (SIW) with transverse slots on the top plane can be used as effective leaky-wave antennas with end-fire radiation capabilities. Such antennas have been investigated for maximum directivity conditions, but in practice the gain is decisive, which often drops down due to dielectric losses. Therefore we investigate such antennas considering the important loss mechanisms to get an optimized aperture illumination. For this goal a modal analysis is made to derive the phase and attenuation constant of the leaky mode for different slot length at a fixed frequency whereas the phase constant is fixed by an iterative procedure to get a main beam near end-fire. With this method, a look-up table is generated which is used for an optimization routine to get the slot length and the width of the SIW for a number of antenna sectors. The antenna is then simulated with a new magnetic/electric field fast integral equation framework we have developed in the last months.

17:30 ***Accurate Equivalent Circuit Model for Centred Inclined Coupling Slots in Planar Slotted Waveguide Array Feeds...N/A***

Soumya Sheel (Queensland University of Technology, Australia)

Planar slot arrays can be fed using a feed waveguide with resonant centred-inclined coupling slots in its broad wall. The inclined slots couple power into radiating branches, arranged side-by-side and orthogonal to the feed waveguide. The conventional design procedure for the feed is based on the assumption that all scattering parameters of coupling junctions are either in-phase or out-of-phase at resonance. This assumption becomes invalid for small tilt angles and wide slots. The conventional design method also ignores internal higher-order mode coupling between the slots of the feed network. This paper presents an improved model that takes phase discrepancies and higher-order coupling into account. The benefits of the new model are demonstrated using a design example.

RA2: Reflector Antennas

Room: Royal I

Chairs: Di Li (National Astronomical Observatories, Chinese Academy of Sciences, China), Gianpietro Marchiori (EIE Group Srl, Italy)

16:10 ***Results of the radio optical modeling and application of the new radio holography method of the RATAN-600 radio telescope surface diagnosis...177***

Vladimir Khaikin (The Special Astrophysical Observatory, RAS, Russia); Mikhail Lebedev, Nina Ovchinnikova and Anatoly Ripak (Special Astrophysical Observatory of Russian Academy of Sciences, Russia)

We describe a new radio holography method of the RATAN-600 radio telescope antenna diagnosis and adjustment, using the radial movement of the reference panel. We present the results of geometric optical ray tracing of the "South + Flat" antenna system in the autocollimation mode and radio optical modeling of the hologram recording and field reconstruction procedure, taking noise into account. Estimates for necessary isolation and acceptable spatial separation be¬tween transmitting and receiving feeds, geometrical tolerances, and requirements to the reference panel motion control are discussed. The experimental results of the method application to the diagnosis of radial errors in the positioning of panels of the RATAN-600 main mirror are reported.

16:30 ***Aperture field recovery of a reflector radio telescope using Phase shifting holography...N/A***

Anatoly Ripak (Special Astrophysical Observatory of Russian Academy of Sciences, Russia); Vladimir Khaikin (The Special Astrophysical Observatory, RAS, Russia); Mikhail Lebedev (Special Astrophysical Observatory of Russian Academy of Sciences, Russia); Gary Junkin (Autonomous University of Barcelona, Spain)

A new method was recently proposed for reconstructing the aperture field of a reflector radio telescope by recording three holograms having fixed phase shifts of the reference wave. Mathematical analysis and simulation of the method in the autocollimation mode of the RATAN-600 radio telescope were performed and initial experimental results are presented. Using this method on a radio telescope does not require special receiving equipment and a standard radio astronomy receiver can be used for holography measurements with a coherent remote ground or space signal source. This method is suitable not only for the RATAN-600 antenna measurements, but for any ground based or space reflector antenna with an active surface.

16:50 ***Radiation Characteristics of Gregorian Antennas with Resonant Size Reflectors...182***

Oleg I Sukharevsky, Sergey Nechitaylo and Vitaliy Vasilets (Ivan Kozhedub Kharkiv National University of Air Forces, Ukraine)

The iterative calculation method for radiation characteristics of Gregorian antenna is proposed for resonant frequency range. The method accounts for interactions between reflectors. Proposed procedure uses calculation method for electromagnetic scattering by conducting unclosed screens with finite thickness for each iteration. Last one is based on using the E-field integral equation that takes into consideration approximate surface impedance boundary conditions (SIBC). Radiation patterns for Gregorian antenna have been obtained for different sizes of subreflector and feed placement. The number of iterations has been estimated for obtaining stable radiation pattern data.

17:10 ***Design and Analysis of Single Beam Parabolic Reflector Antenna in LTCC for Millimeter Wave Automotive Radar...186***

Dong Park (Member, Korea)

This paper designs and analyzes radar antennas for automobiles that can operate at 77 GHz. This radar antenna is designed on LTCC substrate for highly integrated module. The LTCC substrate has a parabolic reflector at an arbitrary position to improve the antenna pattern. A monopole antenna with a parabolic reflector has dual beam characteristics. That is, the central portion of the pattern is reduced. Therefore, this paper adds an air layer in the LTCC substrate to improve this disadvantage. As a result, the pattern has been improved to have a single beam characteristic. This paper designs and analyzes a single beam parabolic reflector antenna for a highly integrated module that can operate in the millimeter wave. This paper also suggests the possibility of integration of patch antennas for long distance radar systems.

SP2: Signal Processing & Imaging 2

Room: Royal J

Chairs: Alon Eilam (Technion - Israel Institute of Technology, Israel), Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy)

16:10 ***Advanced Microwave Imaging with Compressive Processing - Concepts, Methods, and Applications...189***

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

Research Center, Italy); Marco Salucci (ELEDIA Research Center, Italy)

In this work, an overview of the main concepts when using Compressive Processing (CP)-based methods for microwave imaging is reported. The main theoretical aspects and conditions, namely the sparseness of the unknowns with respect to the representative basis and the incoherence of the measured data encoded within the Restrict Isometry Property (RIP) of the problem matrix linking the data to the unknowns, are provided, enabling the use of efficient CP inversion tools. Simple examples are reported, aimed at illustrating the effectiveness of the presented theory.

16:40 ***Moving Target Detection and Imaging Using a Single-Channel SAR...193***

Ariel Gaibel (Tel Aviv University & IDF, Israel); Amir Boag (Tel Aviv University, Israel)

A single channel SAR algorithm, which detects moving targets, finds their velocity vectors, and forms their focused images is proposed. To find both the range and cross range velocities, a circular data collection path is considered, thus providing the flexibility to control the azimuth angle vs. slow time variation over the synthetic aperture. The backprojection approach is adapted for the task of accurate imaging of moving targets. A highly efficient back-projection algorithm is developed using multilevel interpolation and aggregation of coarse images based on partial data sets.

17:00 ***Up-conversion MMW imaging system based on Glow Discharge Detector row attached to commercial contact image sensor...197***

Lidor Kahana (Ariel University, Israel)

The proposed two-dimensional millimeter wave imaging system is based on a row of very inexpensive detectors called glow discharge detectors (GDD) and a commercially inexpensive contact image sensor (CIS). The up-conversion detection method is based on detection of the light changes in luminous intensity of the GDD pixels due to the absorption of the MMW radiation. A Row of 44 GDD pixels was attached to a commercial CIS, constructing an MMW row sensor (MRS). The CIS samples the GDD row emitted light using a 1728 photo sensors array, then convert the analog data to digital data using a standard ADC board. In order to construct a full 2D MMW image of an object, the MRS is laid on top of a computerized X/Y translation stage similar to the mechanism of scanners and copy machines. A digital lock-in amplifier software algorithm is used to improve the sensitivity and SNR of the MRS signals. The entire system is controlled using LabVIEW software. The MRS is positioned in the image plane of a quasi-optical set up composed of MMW projection system and large aperture spherical imaging mirror. The projection system is used to illuminate the object. It is composed of an MMW source located at the focal point of an off-axis a parabolic mirror (OPM), which collimates the MMW radiation directed to the object. The large aperture imaging mirror is used to collect the MMW reflections from the object, creating an image at the location of the MRS. By scanning the image plane using the computerized X/Y translator, a 2D MMW image will be obtained.

17:20 ***Pure Play Ultrasonic 3D Positioning System with Unsynchronized Beacons and Receivers...202***

Guy Dascalu, Omer Movshovits and Alon Eilam (Technion - Israel Institute of Technology, Israel)

This paper describes a work on 3D ultrasonic positioning system for mobile devices such as cellular phones and IoT devices with built-in microphones. The uniqueness of the described system is its ability to provide simultaneous and accurate positioning of multiple devices, based on ultrasonic signals transmitted by stationary beacons while the devices are sampling the signals by their internal, unsynchronized clocks. Auxiliary information required for synchronization is collected and broadcasted by a monitor unit through an ultrasonic modem. The system is considered to be "pure play ultrasonic" since no wiring or radio transmission is used. The number of devices positioned simultaneously is unlimited since they do not emit any energy, and their position calculation is performed locally. In the demonstrated system the positioned devices were cellular phones, operating at a sampling rate of 44,100 samples per second. This sampling rate enables using ultrasonic signals beyond the human hearing range.

17:40 ***Performance Analysis of Imaging Algorithms for Landmine Detection...208***

Rishitha Chitteti, Vishnuvardhan Reddy Y and Lakshmi Durga Edara (National Institute of Technology, Andhra Pradesh, India); Kishore Kumar Puli (National Institute of Technology Andhra Pradesh, India)

Landmines being dangerous and posing a great a threat to mankind, need to be detected and identified. Different methods from which Ground Penetrating Radar (GPR) and the most widely used Synthetic Aperture Radar(SAR) is dealt and an innovative way of detection using synthetical data and different migration algorithms namely Backprojection and Kirchhoff migration for 2-D and 3-D imaging is proposed and analyzed.

Tuesday, November 5

Tuesday, November 5 9:00 - 10:50

CS3: Innovative Responses to Communications Challenges

Room: Grand A

Chair: Steve Weinstein (CTTC Group, USA)

9:00 ***Enhancing Tracking Accuracy with Exploitation of Mobile Unit Orientation and Antenna Pattern...213***

Gaddi Blumrosen (Bar Ilan University, Israel)

Localization of Mobile Unit (MU) is essential in many applications. Outdoor localization has an accuracy that degrades rapidly with scattered dynamic environment and in indoor environment, and sometimes due to lack of GPS connectivity. Current methods for tracking are based on time of flight or power measurements and usually are split to range estimation from fix anchor points, and then aggregation of the range estimation to estimate the MU location. The antenna pattern of the MU is assumed erroneously as non-directional (isomorphic). Recently, with more accurate inertial sensor available in MUs, the mobile node orientation can be estimated. In this work, we examine the potential for tracking enhancement with exploitation of instantaneous MU orientation and prior knowledge about antenna directionality by developing the CRLB for the directional case. We model into the solution different error sources. Then we suggest directions for implementation scheme that can exploit the new available information.

9:20 ***MMW coherence detection for the 5th generation of cellular communication...219***

Moti Ben Laish (Ben Gurion University of the Negev, Israel); Daniel Rozban (Ariel University & Ariel University, Israel); Amir Abramovich (Ariel University, Israel); Yitzhak Yitzhaky and Natan Kopeika (Ben-Gurion University of the Negev, Israel); Avihai Aharon (Ariel University & Ben-Gurion University, Israel)

The demand for millimeter wave (MMW) wireless communication systems has increased in recent years due to new technologies especially the New Radio standard (5G). In the last years, new MMW detectors found in research. In this paper, we examine a new detection method was based on up-conversion of the MMW to visible light. A miniature neon indicator plasma lamp as a glow discharge detector (GDD) and commercial photodiode were used in this detector scheme. This work focuses on the design of a new coherence detector setup and measuring its parameters like noise equivalent power and bandwidth. The detector measurements were performed in the 100 GHz region.

9:40 ***Broadcast Approach for the Information Bottleneck Channel...222***

Shlomo (Shitz) Shamai (The Technion, Israel); Avi Steiner (Technion, Israel)

This work considers a layered coding approach for efficient transmission of data over a wireless block fading channel, connected to a limited capacity reliable link, known as the bottleneck

channel. Two main approaches are considered, the first is an oblivious approach, where the sampled noisy observations are compressed and transmitted over the bottleneck channel without having any knowledge of the original information codebook. This is compared to a decode-forward (non-oblivious) approach where the sampled noisy data is decoded, and whatever is successfully decoded is reliably transmitted over the bottleneck channel. In both settings, it is possible to analytically describe in closed form expressions, the optimal continuous layering power distribution which maximizes the average achievable rate. Numerical results demonstrate the achievable broadcasting rate in the limit of continuous layering.

10:00 ***SVM based method for multi-equalizer optimization...227***

Benjamin R Taub (Mellanox Technnologies, Israel)

Optimization of equalization parameters in SerDes systems is one of the most challenging problems in modern communication systems. The difficulty of properly tuning equalizer parameters for minimum bit error rate (MBER) increases as channel loss becomes harder to overcome, driving design into more complex equalizers. The complexity of equalizer and forward error correction (FEC) systems are directly determined by the equalizer's ability to correct intersymbol interference (ISI) from the channel. In this work, the author presents a novel method of tuning equalizer parameters that specifically focuses on MBER and eye dimensions over traditional minimum mean squared error (MMSE) based methods.

DC3: Special Session on Power Amplifiers

Room: Grand B

Chair: Oren Eliezer (PHAZR & TallannQuest, USA)

9:00 ***Efficient and Linear GaN Power Amplifiers for Broadband High PAPR Signals...N/A***

Zoya Popović (University of Colorado at Boulder, USA)

Efficient and Linear GaN Power Amplifiers for Broadband High PAPR Signals

9:35 ***Reconfigurable Power Amplifiers...N/A***

Charles Campbell (Qorvo, USA)

There are a number of applications requiring power amplifiers to operate in multiple, relatively narrow frequency bands with greatly differing center frequencies. A high level of amplifier performance is required within the narrow operating bands but not outside of these bands. To cover multiple bands with a single amplifier MMIC would require either a wideband power amplifier, switched individual amplifiers or a single amplifier tuned for multiple frequency bands. Wideband amplifier MMICs are available but generally have a lower level of performance when compared to amplifiers tuned for the individual bands and are difficult to scale to higher output power levels. Wideband amplifiers also have rated gain and output power capability outside of the operating bands of interest creating a potentially undesirable situation with regard to out of band emissions, harmonic level and amplifier stability. RF switching between individual amplifiers that have been optimized for each frequency range would require a large amount of semiconductor real estate and suffer reduced performance due to the insertion loss of wideband high power RF switches. Past efforts to develop amplifiers tuned for multiple bands have achieved limited success and the approach is not commonly used. To address this a high power amplifier circuit architecture has been developed that is electronically reconfigurable for operation in multiple frequency bands, maintains a high level of performance, can be realized in a small die size and scales to higher output power levels. The approach is compatible with modern MMIC process technology and utilizes bias and control voltage levels typical of existing RF switch and amplifier functions. This talk will start with a discussion of the realization of MMIC compatible reconfigurable circuit elements and the associated RF switch and bias circuits. A design methodology to synthesize frequency reconfigurable matching networks will then be presented. Finally, these ideas will be applied to a 25W GaN S/X-band PA MMIC design. Measured results will be presented illustrating the advantages of the reconfigurable approach over existing wideband MMICs.

10:10 ***CMOS Power Amplifiers and Transmitters: The Evolution from 'Digital-Friendly' RF to 'Digital' RF...N/A***

Jeffrey Walling (Qualcomm, San Diego, CA, USA)

Since the advent of investigation into CMOS RF circuits, the power amplifier (PA) has attracted perhaps the most investigative attention of any single block component. Exploration in both linear and switching CMOS PAs dates to the late 1990s. It is noted that the properties that are desirable for realization of a linear PA (e.g., high-gm, high output resistance, high operation voltage) have been traded off for properties that are more advantageous for switching PAs (e.g., low-on resistance, high on-to-off ratio, low device parasitic capacitance, fast turn-on/turn-off time). Hence, many designers turned their focus to designing switching PAs; the caveat is that switching amplifiers require linearization circuits when they are used to amplify non-constant envelope modulation. In this talk, general concepts of CMOS linear and switching amplifiers will be introduced and discussed, including some of the general tradeoffs that are associated with each topology. Next, a focus will be made to linearization of a switching amplifier using both analog and digital techniques, including supply-modulation, pulse-width modulation and outphasing. Examples of each of the techniques will be presented. Finally, the concept of "digital" power amplifiers will be introduced and compared directly to linear PA counterparts. Noting that a DPA is actually a full transceiver front-end, including frequency translation, data conversion and front-end amplification, several examples of DPAs and their implementations will be presented, with an eye toward future deployment in more complex transceiver systems.

SR3: Radar Systems and Applications II

Room: Grand C

Chair: Vishal Riche (InnoSent GmbH, Germany)

9:00 ***Aspects of automotive radar systems...N/A***

Wolfgang Boesch (Graz University of Technology & Institute of Microwave and Photonic Engineering, Austria)

Here I will present fundamental principles of radar systems, explain concepts of todays and future automotive radars and show recent developments of target stimulations for autonomous vehicle testing.

9:30 ***Test and Evaluation of Cognitive EA systems - Requirements for future test systems...231***

Dan Pleasant (Keysight Technologies, USA)

While the world has been hard at work developing cognitive AI-based approaches to electronic attack, little thought has been given to the ways in which such EA systems must be tested and their performance evaluated against various threats. The common parametric test techniques that have been used in the past will not be sufficient. This paper examines the problem and finds that there are two major areas of interest: First, a closed-loop test system is required; and second, a simplified method of evaluating the effectiveness of a jammer must be implemented. The paper will present potential test system architectures, highlight the gaps in the available test technologies, and discuss at a high level the considerations that must be taken into account when evaluating EA system effectiveness.

9:50 ***Contactless Gas Mixture Measurements Using Distributed and Synchronized Low-Cost Millimeter-Wave FMCW Radar Sensors...235***

Andreas Och (DICE GmbH & Co KG, Austria & Friedrich-Alexander University of Erlangen-Nuremberg, Germany); Jochen Schrattenecker (Intel Austria GmbH, Austria); Stefan Schuster (Voestalpine Stahl Gmbh & Institute for Communications and Information Engineering, Austria); Patrick Hölzl (DICE GmbH & Co KG, Austria); Philipp Freidl (Infineon Technologies Austria AG, Austria); Robert Weigel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany)

In a multitude of industrial processes, various sensing technologies are employed to monitor gaseous substances. However, many traditional sensor types are not suitable for operation under harsh environmental conditions. Radar-based time-of-flight permittivity measurements have been proposed as alternative but suffer from high cost and limited accuracy in highly

cluttered industrial plants. We propose a novel concept that utilizes two synchronized low-cost frequency-modulated continuous-wave radar sensors for a direct transmission measurement with increased robustness and accuracy. A prototype based on fully-integrated millimeter-wave radar transceivers was realized and multiple measurements demonstrate a significant improvement to previously published techniques due to higher signal-to-noise ratio and compensation of systematic setup induced errors.

10:10 ***No-contact High-Frequency Large-Bandwith GPR scanner for floor investigation...241***

Massimiliano Pieraccini and Lapo Miccinesi (University of Florence, Italy)

In this paper a no-contact high-frequency large-bandwidth ground penetrating radar (GPR) scanner specially designed for investigating floors is presented. It operates at 10 GHz central frequency with 4 GHz bandwidth. Its mechanical positioner is able to scan a surface 0.3 m wide and 1.9 m large. The aim of this radar survey is to gather information about the shallow layers (coat, screed, embedded heating or water pipes) up to 0.5 m depth.

10:30 ***Partially coherent radar...N/A***

Vitali Kozlov (Tel Aviv University, Israel); Rony Komissarov (Tel Avivl University, Israel); Dmitry Filonov and Pavel Ginzburg (Tel Aviv University, Israel)

Range resolution, the ability to distinguish between two closely situated targets, is one of the key characteristics of a radar. Vast majority of conventional systems utilize wide frequency range to achieve superior range resolution, which is inversely proportional to the bandwidth of the transmitted radar signal. Here we demonstrate a different concept, which possesses superior range resolution that is almost completely free of bandwidth limitations. Statistical degree of freedom is utilized for this purpose. In particular, we implemented a sweep over the coherence length of the transmitted signal, and experimentally demonstrate an improvement of over an order of magnitude in resolving targets, compared to standard coherent radars with the same bandwidth. The improved resolution comes on the expense of the scanning time. Partially coherent radar provides solutions in cases where high range resolution and accuracy are required, while an available bandwidth is limited, as is the case for the autonomous cars and imaging to name just few.

T3: Advances in the Linearization of Microwave and Millimeter-wave Power Amplifiers

Room 3

This talk provides the various trade offs involved in the decision to include linearization in the design of microwave and millimeter-wave power amplifiers. Emphasis will be placed on efficiently producing linear power over very wide (multi-GHz and octave) bandwidths and at frequencies to 100 GHz and above. The latest developments in power amplifier technology, including millimeter-wave GaN devices will be considered. The application of linearization to linear photonic transmission systems will also be considered.

9:00 ***Advances in the Linearization of Microwave and Millimeter-wave Power Amplifiers...N/A***

Allen Katz (The College of New Jersey, USA)

This talk provides the various trade offs involved in the decision to include linearization in the design of microwave and millimeter-wave power amplifiers. Emphasis will be placed on efficiently producing linear power over very wide (multi-GHz and octave) bandwidths and at frequencies to 100 GHz and above. The latest developments in power amplifier technology, including millimeter-wave GaN devices will be considered. The application of linearization to linear photonic transmission systems will also be considered.

WIE: Women in Engineering

Room 5

AP3: Antenna Arrays

Room: Royal H

Chairs: Andrea Massa (University of Trento, Italy), Andrey Zhuravlev (Bauman Moscow State Technical University, Russia)

9:00 ***Optimal Trade-Off Phased-Arrays for Future Generation Radars and Communication Systems...247***

Andrea Massa (University of Trento, Italy); Nicola Anselmi (ELEDIA Research Center, Italy); Giorgio Gottardi (ELEDIA Research Center, University of Trento, Italy); Robert Mailloux (University of Trento, Italy); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Lorenzo Poli (ELEDIA Research Center, University of Trento, Italy); Paolo Rocca (University of Trento, Italy)

Recent advances on the synthesis and design of unconventional arrays for future generation radar and communications systems are presented in this work. The proposed methodologies are aimed at simplifying the array beam forming network (BFN) by means of innovative clustering/tiling strategies, jointly pursuing the goal of limiting the unavoidable reduction of the array performance in terms of (i) radiation pattern features and (ii) link Quality-of-Service (QoS). Selected numerical examples are reported in order to prove the effectiveness of the proposed methods.

9:30 ***On the Optimal Positioning of Antennas in the Microwave Personnel Screening System with Inverse Synthetic Aperture...253***

Andrey Zhuravlev and Vladimir Razevig (Bauman Moscow State Technical University, Russia); Ge Dong (Tsinghua University, China)

In this paper we consider strategies of positioning of antennas in a new type of microwave personnel screening system, in which the motion of the subject could be used to create synthetic aperture. For this purpose we simulate 2D point spread functions (PSF) of the screening system depending on the number of receive and transmit antennas in a horizontal section of viewing geometry. Optimization is considered to find how positioning of a fixed number of transmit and receive antennas can improve PSF of the radar system.

9:50 ***Spatial Suppression of Jamming Signals in Extreme Conditions...257***

Yefim S. Poberezhskiy (Consultant, Communications & Signal Processing, USA); Gennady Y. Poberezhskiy (Raytheon Space and Airborne Systems, USA)

Two methods of spatial suppression of jamming signals (JSs) in extreme conditions are described and analyzed. The first method protects a victim receiver (Rx) with an antenna array from extremely strong JSs capable not only of desensitizing the Rx but also damaging its input circuits. The second method protects a victim Rx from a very large number of JSs when their angles of arrival differ from that of a desired signal. These methods significantly differ from each other and from conventional nulling, beamforming, and diversity combining. Despite the differences, their joint use in various combinations is still possible and can be useful in many cases.

10:10 ***Computational Analysis of Nanoantenna Arrays for Nanoparticle Detection...263***

Goktug Isiklar and Ozgur Ergul (Middle East Technical University, Turkey)

We present computational analysis of nanoantenna arrays when they are used to detect and identify nearby nanoparticles. Solutions of frequency-domain scattering problems are performed by using a surface-integral-equation formulation that is suitable for composite structures involving metallic, dielectric, magnetic, and/or plasmonic objects. Acceleration is further achieved via the multilevel fast multipole algorithm that is developed for composite structures. Numerical results demonstrate the feasibility of particle detection and identification, even with sparse arrays with relatively large periodicities.

10:30 ***Optimization of Thinned Antenna Phased Arrays for Low Sidelobe Level...265***

Rotem Gal Katzir (Ben Gurion University of the negev, Israel); Reuven Shavit (Ben-Gurion University, Israel)

Antenna arrays are being used in radar, wireless or satellite communication systems. These applications demand for high gain or directional antennas to decrease interference from other applications. Furthermore, the necessity for new methods of thinning of antenna arrays arises, due to the popularity of aperture sharing in multifunction systems. A thinned configuration is achieved by strategically eliminating elements from the array to form a specific geometry and optimize a specific set of radiation characteristics. It is known that the side lobes of the array pattern cause interferences in communication towards undesired directions and therefore for many arrays applications the main requirement is a design with low SLL. In this study the main design goal was to maintain the maximum sidelobes level (SLL) at -30 dB and achieve optimal performance with the minimum number of elements.

BM1: Novel Technologies

Room: Royal I

Chairs: Amir Landesberg (Technion, Israel), Yoav Shechtman (Technion, Israel Institute of Technology, Israel)

9:00 ***Synthetic Biology - when biology and electronics meet...N/A***

Ramez Daniel (Israel Institute of Technology, Israel)

In this talk, I will describe two different directions that are correlated: (1) Synthetic biology, the implementation of design principles and approaches from electrical engineering into genetic circuits in living cells. As a central goal of this emerging field is to create robust and large-scale genetic networks in living cells that can directly interact with bio-compounds for processing and actuation. I will analyze the pros and cons of implementing analog versus digital computation in living cells, and then, I will show our recent work which describes the implementation of neuromorphic computing in living cells in analogous to artificial intelligence. Natural biological systems consist of imprecise units that collectively interact to reliably perform computationally intensive tasks. Synthetic computation in living cells, in contrast, is largely inspired by precise computer engineering principles and so has not yet achieved the characteristics of natural systems. Here, we demonstrate that synthetic neuromorphic genetic circuits can be engineered to efficiently solve sophisticated computational functions in living cells. Such genetic circuits smoothly integrate signal processing and decision making to implement data classifiers, which capture the perceptual computing capabilities of artificial neural networks (ANNs). We first established a fundamental transformation of principles and architectures from ANNs to synthetic gene networks, then applied these principles and architectures in Escherichia coli cells to create fuzzy computation, exploiting cooperativity, feedback loops, and binding reactions. Both theoretically and experimentally our circuits can be modularly scaled by cascading multiple layers of genetic classifiers to achieve complex logic functions, with a few transcription factors. These circuits are controlled in situ by artificial-intelligence algorithms (e.g., gradient descent and backpropagation), to approximate classification. Finally, we applied neuro-inspired data converters to encode analog cellular information by digital multi-bit decision. This study marks an important step towards adaptive synthetic biology, which offers promise for emerging biotechnology and therapeutic applications. (2) Cytomorphic electronics, which was introduced recently in the field of design bio-inspired ultra-low power analog-digital circuits. It aims to mimic biochemical reactions and genetic circuits using electronics, to simulate cells, organs, and tissues taking into consideration stochastic behavior of a single cell and cell-to-cell variation, nonlinearity, distortions and cross-talks using integrated electronics. In this talk, we first show that two-terminal memristive devices can capture the non-linear and stochastic behavior of biochemical reactions. Then, we present the design of several building blocks based on analog memristive circuits that inherently model the biophysical mechanisms of gene expression. The circuits model induction by small molecules, activation and repression by transcription factors, biological promoters, cooperative binding, and transcriptional and translational regulation of gene expression. Finally, we utilize the building blocks to form complex mixed-signal networks that can simulate the delay-induced oscillator.

9:30 ***Design of a Compact "Multi-Media" UWB Antenna for Microwave Medical Imaging...N/A***

Steve Kruppa (Elscint Tomography, Israel)

A novel, multi-environment Ultra-Wide Band (UWB) antenna/ transducer has been developed for in vitro and in vivo microwave medical imaging platforms. The antenna exhibits excellent scalability and wide operating bandwidths, demonstrating robust impedance matching capabilities and reduced mutual coupling effects when deployed proximal to biological tissue or fully submerged within a high-permittivity coupling fluid. Moreover, multiple antennae can be deployed in a variety of compact array configurations suitable for beam-steering, Time Reversal, or other multi-sensor configurations.

9:50 ***Innovative Machine Learning Techniques for Biomedical Imaging...267***

Marco Salucci and Davide Marcantonio (ELEDIA Research Center, Italy); Maokun Li (Tsinghua University, China); Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Paolo Rocca and Andrea Massa (University of Trento, Italy)

Machine Learning (ML) is a powerful paradigm to solve several inverse problems arising in biomedical imaging with very high computational efficiency. As a matter of fact, learning-by-examples (LBE) strategies can be successfully exploited to predict the status of the domain under investigation (DoI) starting from measured data with almost real-time performance. Some recent advances of ML as applied to brain stroke detection, classification, and localization, as well as to human chest monitoring are presented. An illustrative example concerned with a novel LBE strategy for the real-time prediction of the lungs dimensions from electrical impedance tomography (EIT) measurements is given, as well.

10:10 ***Optimization of transmitted power of horn antenna for biomedical applications...270***

Shailendra Rajput, Konstantin Komoshvili, Stella Aronov, Ayan Barbora, Praveen Patnaik, Jacob Levitan and Asher Yahalom (Ariel University, Israel)

Lung cancer is considered the deadliest type of cancer for humans and is often diagnosed at the incurable stage. Till now, no effective methods for early diagnosis and treatment of lung cancer have been developed. This short paper presents preliminary studies on millimeter-wave (MMW) effect on yeast cells. It is well known that yeasts are representative of human cells, in many aspects of fundamental cellular processes. Initially, transmitted power from the horn antenna is optimized for both near-field and far-field regions. The studies were performed for the W-band of MMWs (75-110 GHz). Preliminary studies suggested that the MMW radiations with a maximum incident power density do not alter the number of colonies of yeast cells.

QEM1: Special Session - Quantum & Nano EM 1

Room: Royal J

Chairs: Dmitri Mogilevtsev (Institute of Physics, National Academy of Sciences of Belarus, Belarus), Jeffrey H Shapiro (Massachusetts Institute of Technology, USA)

9:00 ***The Quantum Illumination Story...274***

Jeffrey H Shapiro (Massachusetts Institute of Technology, USA)

Superposition and entanglement, the quintessential characteristics of quantum physics, have been shown to provide communication, computation, and sensing capabilities that go beyond what classical physics will permit. It is natural, therefore, to explore their application to radar, despite the fact that decoherence---caused by the loss and noise encountered in radar sensing---destroys these fragile quantum properties. This paper tells the story of ``quantum illumination'', an entanglement-based approach to quantum radar, from its inception to its current understanding. Remarkably, despite loss and noise that destroys its initial entanglement, quantum illumination does offer a target-detection performance improvement over a classical radar of the same transmitted energy. A realistic assessment of that improvement's utility, however, shows that its value is severely limited. Nevertheless, the fact that entanglement can be of value on an entanglement-breaking channel---the meta-lesson of the quantum illumination story---should spur continued research on quantum radar.

9:30 ***Quantum Noise Radar: Assessing Quantum Correlations...278***

Dmitri Mogilevtsev (Institute of Physics, National Academy of Sciences of Belarus, Belarus); Gregory Slepyan and Amir Boag (Tel Aviv University, Israel); Alexander Mikhalychev, Ilya Karuseichyk, Ilya Peshko and Alexander Nizovtsev (IPNASB, Belarus)

We suggest overcoming the "Rayleigh catastrophe" and reaching superresolution for imaging with both spatially and temporally-correlated field of a superradiant quantum antenna. Considering far-field radiation of two interacting spontaneously emitting two-level systems, we show that for the measurement of the temporally-delayed second-order correlation function of the scattered field, the Fisher information does not tend to zero with diminishing the distance be-tween a pair of scatterers even for non-sharp time-averaged detection. For position estimation of a larger number of scatterers, measurement of the time-delayed function is able to provide a considerable accuracy gain over the zero-delayed function. We show also that the superresolution with the considered quantum antenna can be achieved for both near-field imaging and estimating parameters of the antenna

10:00 ***Quantum emission between the weak and strong coupling regimes...281***

Iñigo Liberal (Public University of Navarre, Spain)

The emission properties of single-photon sources attached to photonic nanostructures in the weak and strong coupling regimes have been intensively studied. However, often new opportunities arise in physical systems that operate at intermediate regimes between the more studied extreme cases. Here, we analyze the emission properties of a two-level system coupled to a two-mode cavity. Our analysis demonstrates that there is an intermediate regime, between the weak and strong coupling regimes, which offers an additional degree of freedom in controlling the bandwidth of a single-photon source, even when it is incoherently excited. In turn, this degree of freedom can be harnessed to decouple efficiency and bandwidth, thus bringing additional flexibility in the design of efficient photon sources with controllable bandwidth.

10:30 ***Interaction of Nano-Rectenna with Thermal Light: Quantum-Optical Theory for Solar Cell Applications...285***

Timor Gilad, Amir Boag and Gregory Slepyan (Tel Aviv University, Israel)

A quantum optical theory of antenna-coupled rectifying diodes is developed. The theory is based on the Landauer-Büttiker model of charge transport combined with the canonical light quantization applied to the nano-antenna. The theory is universal with respect to the type of diode and antenna and free from the limitations over the value of light intensity. It is shown, that ignoring the quantum origin of thermal light is able to produce unphysical results in the rectenna modeling for solar cells applications. We apply the theory to various kinds of rectifiers (MIM-diodes, molecular diodes, organic diodes, geometric diodes, and spin diodes) and compare their potential performance in solar cell implementations. The theory is also promising for applications in the engineering of detectors, sensors, and power harvesting devices.

Tuesday, November 5 11:10 - 13:00

PT0: Packaging & Thermal Management

Room: Grand A

Chairs: Aviv Ronen (Rafael, USA), Gennady Ziskind (Ben-Gurion University of the Negev, Israel)

11:10 ***Introductory Remarks...N/A***

Avi Bar Cohen (Raytheon, USA); Aviv Ronen (Rafael, Israel); Yoav Peles (UCF, USA); David Ratner (Rafael, Israel); Gennady Ziskind (BGU, Israel)

Introduction

11:20 ***Two-Phase Electronics Cooling...N/A***

Bryan Muzyka (Advanced Cooling Technologies, USA)

System level designers consistently demand advanced capabilities and functionality in electronics systems, which inevitably leads to higher power and more waste heat. In many cases, the concentrated power densities create local hot spots, which ultimately cause failure in expensive electronics' components that are critical to operation. This session will review two-phase cooling options to provide solutions for when traditional air and liquid cooling systems face limitations. It will cover both theoretical and practical operating principles, as well as design guidelines. The audience will leave with tools and resources to integrate these systems into current projects. Technologies covered include heat pipes, vapor chambers and pumped two-phase cooling. • Heat pipes and vapor chambers are passive, closed loop, two-phase devices that assist in heat transport or heat spreading in order to reduce electronics' case temperatures. They take advantage of a fluid's high latent heat of vaporization and thermodynamic properties to create very low delta T throughout the thermal device. • Active pumped two-phase systems operate under similar principles, taking advantage of the two-phase fluid properties; with a pump added to the system, extremely high power and long distant transport is achievable.

11:40 ***Vertically Algined Carbon Nantubes for Thermal Packaging Applications...N/A***

Asaf Yaakobovitz (Ben Gurion University of the Negev, Israel)

The continuous miniaturization of electronic devices improves their functionality, but on the other hand, also increases their power density, and thus required improved thermal management solutions. Vertically aligned carbon nanotubes (VA-CNTs), which is a structure that comprises billions on vertically oriented individual carbon nantubes, constitute one of the most promising materials for use as a high-end heat dissipation element. VA-CNTs exhibit high thermal conductivity and large surface area, which make them a highly attractive material for thermal packaging applications. In the present talk we will review some of the works that used VA-CNT as heat transfer elements. In addition, we will show our recent results in which we studied the nature of heat dissipation from VA-CNTs. We have shown that their heat dissipation behavior depends mostly on their height and morphological parameters. VA-CNT can operate as elements that enhance heat convection to the environments (in the case of tall and aligned VA-CNTs), or as elements that enhance heat conduction (in the case of short and disorganized VA-CNTs).

12:00 ***Database for Life Cycle Temperatures and Cooling System Operation Frequencies...N/A***

Aviv Ronen and David Ratner (Rafael, Israel)

A general innovative approach was used for establishing the database. Life cycle scenarios (flight profiles, operation and atmosphere frequencies) are implemented as a combination of boundary conditions in the system thermal model. The model outputs include temperatures and cooling system frequencies through the whole system life cycle for each component. This database can be used for various purposes: - Reliability MTBF calculations - Life cycle test profile design - Manufacturing temperature test profiles - Maintenance concept and procedures

12:20 ***Additive Manufacturing of Electronics...N/A***

Ziv Cohen (NanoDimension, Israel)

Nano-Dimension is the only one in world that can produce 3D PCB board (additive manufacturing), produce the next generation of the PCB technology. As product complexity continues to climb, and smaller, thinner devices packed with added functionality trend upward, moving quickly from design validation to production is a major challenge for the highly competitive electronics industry. Additive manufacturing of electronics provides design engineers with the tools needed to overcome this challenge and gain a competitive advantage. Through a Nano Dimension presentation of real-world examples and use cases in various industries and applications, this session will discuss the power and flexibility of additive manufacturing of electronics and the revolutionary role the DragonFly precision additive manufacturing plays to speed market readiness of PCBs, sensors, RF circuits and more. Attendees will also learn how additive manufacturing systems and materials come together to redefine the boundaries of existing applications and create limitless possibilities for the future.

12:40 ***Development of a PCM-Based Thermal Capacitor with AM Lattice Heat Spreader...N/A***

David Ratner (Rafael, Israel)

Thermal design challenges for mission critical electronic assemblies operating in harsh military environments are abundant. In many cases, the local environment is not conducive to the effective dissipation of heat, and extraordinary means must be provided to ensure that the assembly remains within component thermal limits. The use of thermal capacitors (TC) - high thermal energy storing devices - is an effective method of achieving this goal for transient or periodic scenarios. The use of phase change materials (PCM) is advantageous in TCs due to the high energy to mass ratio afforded by the latent heat of phase change, which is absorbed with minimal temperature rise. Paraffin-based PCMs are a preferred choice for the appropriate temperature range, however their low thermal conductivity requires special means to transfer the heat from electronic subassembly attachment surfaces to the PCM bulk. Properly designed porous metallic structures (e.g., fins) surrounded by PCM allow for the effective distribution of heat within the TC bulk, thus maintaining a reasonable temperature gradient between the melting PCM and electronic components. Due to geometry, strength and/or thermal considerations, 2D or 3D structures may be incorporated. This presentation will present an overview of thermal design considerations and methodology in the development of a PCM thermal capacitor (PCMTC) using a paraffin-based PCM within an additive-manufactured (AM) lattice structure.

DC4: mmW Components

Room: Grand B

Chair: Frank Ellinger (Technische Universität Dresden, Germany)

11:10 ***Energy-efficient RF- and Millimeter-Wave ICs and Frontends for Communications...N/A***

Frank Ellinger (Technische Universität Dresden, Germany)

The talk focuses on energy-efficient RF- and millimeter-wave ICs. A SiGe millimeter-wave wireless transceiver at 190 GHz with data rate of 50 Gb/s drawing a dc power of only 154 mW is presented. A single-core CMOS analog to digital converter with a speed of 24 GS/s and 3 bit resolution is demonstrated. A 2.4 GHz receiver with a power consumption of only 3 µW using aggressive duty-cycling is outlined. Variable gain amplifier concepts are elaborated, which reduce the phase errors in vector modulators simplifying beamforming control. By fast DC/DC converter chips the power consumption of typical power amplifiers can be lowered by 50 %. Bandwidth adaptive RFICs are presented which reduce the power consumption by at least a factor of two. Finally, fully integrated bendable and stretchable thin-film transistor based wireless data transmitter and receiver frontends operating in the MHz-range are outlined.

11:40 ***Trends in MW Front-End technologies...N/A***

Wolfgang Boesch (Graz University of Technology & Institute of Microwave and Photonic Engineering, Austria)

here I would start to present semiconductor technologies, their integration and then talk about PCB, packaging and antenna technologies. Give some examples of 3D printing and show recent highly integrated front-ends.

12:10 ***A 300 GHz Quadrature Down-Converter S-MMIC for Future Terahertz Communication...288***

Iulia Dan, Christopher Grötsch and Benjamin Schoch (University of Stuttgart, Germany); Sandrine Wagner, Laurenz John and Axel Tessmann (Fraunhofer IAF, Germany); Ingmar Kallfass (University of Stuttgart, Germany)

This paper presents a highly broadband quadrature down-converter with a center frequency of 300 GHz and a low-noise amplifier (LNA) with a bandwidth of 80 GHz. The operation frequency between 235 GHz and 315 GHz enables the usage in future wireless high data rate applications. The submillimeter-wave monolithic integrated circuits (S-MMIC) are realized using a 35\,nm metamorphic high electron mobility transistor (mHEMT) technology based on InAlAs/InGaAs. The down-converter integrates a frequency multiplier by four, a buffer amplifier and a passive fundamental I/Q mixer and reaches a conversion gain of -15 dB and an RF bandwidth of 60 GHz. The low-noise amplifier has an average gain of 26 dB over the 3 dB bandwidth. A total conversion gain of the receiver of 11 dB is therefore reached by combining the down-converter and the LNA.

12:30 ***Low-Power K-Band LNA in 45 nm SOI CMOS...294***

Vadim Issakov (Infineon Technologies AG, Germany); Radu Ciocoveanu (Infineon Technologies AG / Friedrich-Alexander University Erlangen-Nuremberg (FAU), Germany)

This work presents a low-power K-band single stage cascode low-noise amplifier (LNA) realized in a 45 nm silicon-on-insulator (SOI) CMOS technology. The circuit uses a tapped-inductor resonator for impedance transformation to achieve simultaneously high gain and good output matching. Furthermore, thanks to a careful floorplaning and the proposed arrangement of inductor terminals, the interconnect losses are minimized. The amplifier achieves a gain of 10.7 dB and a noise figure of 1.6 dB at the center frequency of 20.5 GHz. The circuit achieves a wide 3 dB bandwidth of 15-27 GHz and a linearity of. 10.3 dBm input-referred 1 dB compression point. The LNA consumes only 6 mA from a single 1 V supply. The chip size including the pads is only 0.18 mm2 . The presented LNA achieves a very competitive performance compared to the state of the art.

RD1: Tutorial: MIMO radar and phased array systems

Room: Grand C

Chair: Mario Pauli (Karlsruhe Institute of Technology, Germany)

11:10 ***MIMO radar for monitoring applications...N/A***

Vishal Riche (InnoSent GmbH, Germany)

MIMO radar for monitoring applications Nowadays, security applications require multi detection capability, higher accuracy and higher spatial resolution while keeping a small form factor. In order to solve these challenges, the MIMO concept has been considered as a potential solution. Moreover, MIMO technology has matured enough over the years to be considered for industrial applications. This talk provides an overview of MIMO radar and the challenges that are still under research. The first part will briefly explain the challenges expected in monitoring radar (from security radar to traffic monitoring radar), why MIMO radar is interesting for certain applications and an explanation on how a MIMO radar works. Then, the transmitter part will be describe before looking in detail on the waveform design (FMCW /SFCW /OFDM / DFCW / PMCW). Pros and cons of each waveform and their limitations will be described (interference problem, implementation problem …). The next part will look on spatial resolution and the digital beamforming concept before comparing the different methods existing (delay and sum (Bartlett beamformer), CAPON, MUSIC, compressed sensing …) and what are their pros and cons for industrial application. The last part will talk about hardware implementation, technological limitation, quality and compromise between hardware, preprocessing (radar signal processing) and post processing (tracker, classification) and will present actual MIMO radar developed for monitoring application, their aims and limitations.

12:30 ***Advances in mutual coupling-based calibration in digital phased array systems...N/A***

Caleb Fulton (University of Oklahoma, USA)

As digital phased array systems become increasingly common relative to their analog counterparts, there are new opportunities to test, refine, and improve on a number of emerging techniques that make use of feedback paths afforded by the inherent mutual coupling between transmitting and receiving elements for the purposes of array calibration. This talk will provide updates on increasingly realistic modeling to predict the performance of such schemes on real systems, seeking to determine guidelines for circuit- and system-level engineering decisions that will help achieve the ultimate goal of array self-calibration without the use of any external measurement equipment.

T4: Supply-Modulated Power Amplifiers for Efficiency Enhancement

Room 3

11:10 ***Supply-modulated power amplifiers for efficiency enhancement...N/A***

Zoya Popović (University of Colorado at Boulder, USA)

Supply-modulated power amplifiers for efficiency enhancement

MM1: Special Session - Metamaterials

Room 5

Chairs: Pavel Ginzburg (Tel Aviv University, Israel), Irina Munina (St. Petesburg Electrotechnical University LETI, Russia)

11:10 ***Superdirective dielectric spherical multilayer antennae...298***

Alexey A. Shcherbakov (ITMO University & Moscow Institute of Physics and Technology, Russia); Konstantin Ladutenko, Igor Sushencev and Pavel Belov (ITMO University, Russia)

Dielectric electrically small antennae are attracting high interest due to their promising applications both in optical and microwave bands. Efficiency of such antennas is usually bounded by low directivity. The stochastic optimization procedure is used to demonstrate superdirective designs of small all-dielectric antennas being spherical multilayer structure. The procedure is based on an efficient and accurate rigorous electromagnetic model which allows for performing large scale optimization on personal computers with limited resources. For optimization we compared different stochastic algorithms, and the JADE demonstrated the best performance. The found designs possess the directivity that go beyond the conventional theoretical bounds for antennas smaller than the wavelength and outperform previously attained results.

11:35 ***Limitations of Nonlinear Electromagnetic Isolators...301***

David Fernandes (University of Coimbra - Instituto de Telecomunicações, Portugal); Mario Silveirinha (Universidade de Lisboa - Instituto de Telecomunicações, Portugal)

Here we show that nonlinear platforms may operate in a regime where they behave as a nearly ideal electromagnetic diode, such that the individual excitations of the two ports lead to strongly asymmetric responses. Furthermore, we show that in the lossless regime, typical nonlinear structures despite being nonreciprocal, are time-reversal invariant, and thereby are inherently bi-directional. Hence, such structures cannot provide a robust optical isolation under simultaneous port excitation.

12:00 ***Antenna-Filter-Antenna Based Transmitarray with Beamsteering Capability...305***

Irina Munina (St. Petesburg Electrotechnical University LETI, Russia); Dmitry E Zelenchuk (Queen's University of Belfast, United Kingdom (Great Britain)); Pavel A. Turalchuk (St. Petesburg Electrotechnical University LETI, Russia)

An original approach of an antenna-filter-antenna based transmitarray which consists of the tiles unit cells placed in a plastic holder is considered. Each unit cell represents a passive receiver-transmitter structure with integrated phase-shifter, which can take either of two coding states corresponding 180° phase difference between the states. The transmitarray design supports two orthogonal linear polarizations. An example of a 10x10 element 1-bit beam steering transmitarray operated in C-band is presented. The results of radiation pattern measurements with single and multifeed excitation are shown.

12:20 ***Optically switchable scanning antenna...308***

Dmitry Filonov (Tel Aviv University, Israel); Anna Mikhailovskaya and Dmitry A Dobrykh (ITMO University, Russia); Alexey P. Slobozhanyuk (ITMO University & Australian National University, Russia); Pavel Ginzburg (Tel Aviv University, Israel)

The ability to obtain dynamical control over an antenna radiation pattern is one of the main functions, desired in a vast range of applications, including wireless communications, radars and many others. Widely used approaches include mechanical scanning with antenna apertures and phase switching in arrays. Both of those solutions have severe limitations, related to scanning speeds and implementation costs. Here we propose and experimentally demonstrate a possible paradigm solution, where the antenna pattern switching is achieved with optical signals. Our architecture employs high-quality ceramic-based driven element and optically switchable reflectors. The latter elements are realized with a set of split ring resonators, loaded with a tandem of varactors and photodiodes. Resonant frequency of each reflector is controlled with an incident light illumination. Fast switching between optically driven reflectors allows achieving scanning between several directions, which cover the entire 2π azimuth section. The current architecture can link to a new paradigm shift, where extremely fast optical switching can allow performing high quality scans over the whole three-dimensional space, which is highly demanded in a broad range of modern applications.

12:40 ***Volumetric Metamaterials versus Curved Impedance Surfaces in Scattering Applications...N/A***

Sergei Kosulnikov (School of Electrical Engineering, Tel Aviv University, Israel); Dmitry Filonov and Pavel Ginzburg (Tel Aviv University, Israel)

Artificially created media allow employing material parameters as additional valuable degrees of freedom in tailoring electromagnetic scattering. In particular, metamaterials with either negative permeability or permittivity enable creating deeply subwavelength resonant structures with extremely high scattering cross-sections. However, equivalence principle allows replacing volumetric structures with properly designed curved impedance surfaces, which ensure exactly the same electromagnetic properties. Here we examine this statement from the practical standpoint, considering two structures, having a dipolar magnetic resonance at the same frequency. The first realization is based on arrays of split ring resonators (volumetric metamaterial), while the second structure utilizes 4-arm spiral on a spherical surface (surface impedance realization). An intermediate conclusion is that the surface implementation tends to outperform its volumetric counterpart in the scenario when a single resonance is involved. However, in the case where multiple resonances are overlapping and lossy materials are involved, volumetric realization can have an advantage. The discussed structures are of a significant importance to the field of electrically small antennas, super-directive antennas and super-scatterers, which find a use in wireless communications and radar applications to name just few.

AP4: MIMO and Adaptive Antenna Arrays

Room: Royal H

Chairs: Eran Greenberg (RAFAEL, Israel), Pavel Vilner (Technion & Mellanox, Israel)

11:10 ***Sparse Optimization of Device-Embedded Antenna Arrays for Beamforming Applications...N/A***

Daniel Silverstein and Yehuda Leviatan (Technion, Israel)

Beamforming antenna arrays are used in many real-world applications such as communications and radar. Recently, there is an increased interest in the design of such arrays via sparse optimization. However, these studies usually assume that the antennas are point sources that radiate isotropically in free space. In this paper, we extend the analysis to the case of device-embedded more realistic antennas by considering the current distribution on the antennas and accounting for the antennas' surroundings. To reduce the complexity of the computational scheme involved in this extension, we resort to the reciprocity theorem. The resulting scheme can then be integrated with an existing sparse optimizer and readily applied to the design of beam forming arrays. This scheme is applied to the design of a single beam array comprising Hertzian dipoles embedded in a dielectric substrate above a ground plane. We show that this approach yields a better beam pattern in terms of least squares error than obtained from a conventional uniformly spaced planar array.

11:30 ***Active Cancellation Limitation Analysis for Full Duplex Systems with a Single Antenna...312***

Pavel Vilner (Technion & Mellanox, Israel); Emanuel Cohen (Technion Institute of Technology, Israel)

In this paper the performance limitations of the multi-PA / multi-LNA / single-antenna duplex RF transceiver architecture interconnected by a passive reciprocal electrical network are explored. It is shown that, if the antenna's impedance is allowed to change, as is the case in real environment, either the influence of the PAs' signal output on the SNR or the influence of the PAs' thermal noise on the SNR can be canceled, but not both of them simultaneously. Additionally, it is demonstrated that, if the antenna's impedance is fixed, then it is possible to design a system in which both the SNR impact of the PAs' signals and the SNR impact of the PAs' thermal noise are canceled. The constraint on the amount of the LNAs and the PAs required to achieve this cancellation is demonstrated as well.

11:50 ***LOS Classification of UAV-to-Ground Links in Built-Up Areas...317***

Eran Greenberg (RAFAEL, Israel); Amitay Bar and Edmund Klodzh (Rafael, Israel)

The use of UAVs for various applications is a rapidly growing research field nowadays. Knowledge of the wireless UAV-to-ground propagation channel is crucial for designing an efficient communication system. The presence of LOS is essential for radio network planning and RF coverage prediction. Built-up areas contain a mixture of LOS and NLOS conditions due to buildings shadowing, states which cannot be easily distinguishable. Hence ray-tracing simulations were performed to model the UAV trajectory, the site-specific urban environment and terrain. In this contribution we develop a method to identify the LOS and the NLOS conditions based on the NB and WB channel statistical parameters: received power, K-factor, mean ToA and delay spread, and their combinations. We found that a classification between LOS and NLOS populations based on a single feature leads to poor to moderate performances depending on the feature. However, combing a few features improved the classification performance.

12:10 ***Excitation Faults Detection in Relatively Large Planar Array Antennas, Measured in Short Antenna Ranges...322***

Alexander Georgiev Toshev (Pro Patria Electronics, Hungary)

An effective algorithm for detection and correction of excitation errors in the aperture of relatively large planar array antennas, measured in short antenna ranges (Fresnel distances) is presented. The method comprises a measurement of a quasi far-field radiation pattern of the antenna under test (AUT) at a Fresnel distance, a derivation of a distorted magnitude/phase excitation of the array antenna, an application of a correction on the distorted array excitation and estimation of the actual array excitation, based on the derived and corrected array aperture excitations. The accuracy of the method improves as the directivity of the AUT gets higher. The method is applied for correction of the excitation errors of an X-band planar array antenna and the measurement results are presented and discussed.

BM2: Advanced Image Analyses

Room: Royal I

Chairs: Ramez Daniel (Israel Institute of Technology, Israel), Yoav Shechtman (Technion, Israel Institute of Technology, Israel)

11:10 ***Deep Learning for Analysis and Synthesis of Dense and Multicolor Localization Microscopy...N/A***

Yoav Shechtman (Technion, Israel)

Deep learning has become an extremely effective tool for image classification and image restoration problems. Here, we address two fundamental problems of localization microscopy using machine learning: emitter density, and color determination. Modern microscopy can produce images of biological specimen at very high (super) resolution, by precisely determining the positions of numerous blinking light emitting molecules over time. To achieve fast acquisition time, a high density of molecules is required, which poses a significant challenge in terms of image processing. Existing approaches use elaborate algorithms with many parameters that require tuning and a long computation time. Here, we report an ultra-fast, precise, and parameter-free method for super-resolution microscopy that utilizes deep-learning: by feeding the computer images of dense molecules along with their correct positions, it is trained to automatically produce super-resolution images from blinking data. Next, we demonstrate how neural networks can exploit the chromatic dependence of the point- spread function to classify the colors of single emitters imaged on a grayscale camera. While existing single-molecule methods for spectral classification require additional optical elements in the emission path, e.g. spectral filters, prisms, or phase masks, our neural net correctly identifies static as well as mobile emitters with high efficiency using a standard, unmodified single-channel configuration - based on inherent chromatic aberrations in a standard microscope. Finally, we demonstrate how deep learning can be used to design phase-modulating elements that, when implemented into the imaging path, result in further improved color differentiation between species. While point-spread-function engineering for spectral differentiation has been implemented in various applications in recent years, the optimal way to design such a PSF remains unclear. Here, we use a neural net to perform such design automatically, directly optimizing the desired cost function, namely, simultaneous localization and color-recognition of point emitters.

11:40 ***Parameter-free MRI Reconstruction from Sub-Nyquist Acquisition...N/A***

Efrat Shimron (Technion, Israel)

We develop a novel reconstruction method for parallel MRI, termed Convolution-based Reconstruction for Parallel MRI (CORE-PI). The method is fast, non-iterative, and parameter-free. An experiment with in-vivo data demonstrates its high accuracy.

12:00 ***Comparison of Image Reconstruction Algorithms using Compressive Sensing...326***

Praizy Diana, Pala Sonia and Shashipriya Polepally (National Institute of Technology, Andhra Pradesh, India); Kishore Kumar Puli (National Institute of Technology Andhra Pradesh, India)

There is a huge increase in data in terms of data conversion that effects the performance and complexity of the devices like analog-to-digital converters (ADC).The standard ADC uses the conventional Shannon-Nyquist Theorem which says that sampling frequency should be twice of the maximum frequency. These samples require very huge storage. Compressive sensing(CS) which gives solution to this problem. In CS we decrease the sampling rate much less than the Nyquist rate and reconstruct the original signal.There are different reconstruction algorithms evolved since from its origin each. In this paper, we are making a comparison between the performances of Orthogonal Matching Pursuit(OMP) and Regularized Orthogonal Matching Pursuit(ROMP) algorithms for image reconstruction.

12:20 ***Electric field array detector for millimeter wave assistance on brain tumor resection...332***

Vera Carolina Cardoso, Hugo Dinis and Paulo Mendes (University of Minho, Portugal)

One of the problems associated with brain cancer resection surgeries is the difficulty in distinguishing the tumor from brain parenchyma. Therefore, it is important to find new methods that increase the resection degree, reducing tumor recurrence. Human tissues have a frequency-specific response and laboratory measurements have been demonstrated to detect tumors using low frequency waves. With the use of electromagnetic waves working at 60 GHz, this paper aims to show an effective way to distinguish tumor cells from the surrounding brain parenchyma, based on the difference between dielectric properties of the two tissues. This goal is achieved through the analysis of electric field patterns.

12:40 ***Efficient Probes for Ultra-high-field Magnetic Resonance Microscopy Based on Coupled Ceramic Resonators...336***

Stanislav Glybovski, Sergei Kurdjumov and Pavel Belov (ITMO University, Russia); Elizaveta Nenasheva (Ceramics Co. Ltd, Russia); Andrew Webb (Leiden University Medical Center, The Netherlands); Marine Moussu and Marc Dubois (Institut Fresnel, France); Stefan Enoch (CNRS & Institut Fresnel, France); Redha Abdeddaim (Aix Marseille University, France); Luisa Ciobanu and Boucif Djemai (DRF/I2BM/Neurospin/UNIRS, France)

In this contribution we present a new radiofrequency probe, a dual dielectric resonator used for transmission and reception of RF signals in Magnetic Resonance Microscopy. The probe is designed as a pair of magnetically coupled ceramic rings with the permittivity of 530 resonating at the Larmor frequency of protons at the magnetic field 17 T (730 MHz). The resonators are made of a unique low-loss ferroelectric composite ceramics, which allows doubling the scanned volume with an increased signal-to-noise ratio in comparison to a metal solenoid probe. By adjusting the distance between the resonators and the position of the loop feed placed between them, the probe can be tuned and impedance-matched and does not require capacitors.

QEM2: Special Session - Quantum & Nano EM 2

Room: Royal J

Chair: Gregory Slepyan (Tel Aviv University, Israel)

11:10 ***Merging the Quantum Realm with Induced Electromagnetic Fields...N/A***

Dor Gabay and Amir Natan (Tel Aviv University, Israel); Ali Yilmaz (University of Texas at Austin, USA); Amir Boag (Tel Aviv University, Israel)

Time-dependent Density Functional Theory (TDDFT), a dynamic mean-field theory, formally adopts the Coulomb gauge and accounts only for electrostatic fields. In remedying the Kohn-Sham equation's static nature, retardation is incorporated within a real-space approach of TDDFT by alleviating the a priori assumption of null magnetic fields. In incorporating electrodynamic effects, the associated gauge freedom must be treated by choosing the appropriate gauge-fixing condition. For this reason, the Coulomb and Lorentz gauges are compared within the newly defined Kohn-Sham Hamiltonian. Retarded integrals are evaluated using an accelerated multi-level scheme. The retardation effects arising from two interacting molecular structures, separated by a distance on the order of the external electromagnetic field's wavelength, are thoroughly studied.

11:30 ***Metallic and dielectric nanoantennae to control field-matter interaction in nanophotonics...N/A***

Sergey Gaponenko (National Academy of Sciences of Belarus, Belarus)

The nanoantenna concept has been recently introduced in optics based on systematic research on excited states lifetime engineering through modified density of photon states. Transdisciplinary significance of mutual transfer of the antennae notion for radioengineering and optics has been witnessed lately. In this talk, an overview of nanoantennae-related phenomena in photonics will be presented with emphasis at both metal-based and fully dielectric structures modifying the local properties of space and enabling excited matter lifetime control including inhibition and promotion of quantum transitions rate. Many issues related to lifetime engineering by means of lightwave confinement can be treated in terms of nanoantenna effects bridging radiophysics and optics and providing an efficient route to mimic certain radiophysical devices in optics. This analogy reflects a definite convergence of classical and quantum electrodynamics and offer an efficient computational approach for lifetime engineering in nanophotonics. Bridging quantum (photon emission by an atom or a molecule) and classical (electromagnetic wave control in radioengineering) through operational definition of the local density of photon states is discussed.

11:50 ***Quantum Antenna Emission as a Strong Coupling with Photonic Reservoir...N/A***

Alexei Komarov and Gregory Slepyan (Tel Aviv University, Israel)

A concept of quantum antenna in the regime of strong coupling is proposed. It uses the theory of open quantum systems. Antenna's radiation into space is considered as an interaction with a thermal photonic reservoir. For obtaining antenna's dynamics model, we formulate a set of master equations with a corresponding Lindblad super-operator representing the radiation term. It is shown that strong coupling influences on the radiation pattern of antenna. The total power pattern splits to three components, each of which corresponds to a spectral line in Mollow triplet. Analysis of the dependence of splitting on antenna length, shift of the phase, and Rabi-frequency is presented. The predicted effect opens a way for construction of multi-beam electrically tunable antennas, potentially useful in different nano-devices.

12:10 ***Electrically Driven Vacuum Rabi Oscillations as a Potential Quantum-Optical Device...339***

Ilay Levie and Gregory Slepyan (Tel Aviv University, Israel)

The dynamics of a charge bounded by a chain of coupled artificial atoms, interacting simultaneously with a single mode quantized electromagnetic field inside a cavity, and a constant electrostatic DC field is presented in this work. We develop an extended Jaynes-Cummings model describing this system and solve it both analytically and numerically, with good agreement between the two methods. It is shown that the charge- photon dressed state is modulated with the Bloch frequency due to the interaction with the DC field. This enables to control the quantum state of light by adiabatically changing the DC field. This novel effect might be important for the application of optical modulators, quantum computing and electrically controlled quantum antennas.

Tuesday, November 5 14:20 - 16:10

DC5: Circuits and Techniques

Room: Grand B

Chair: Vadim Issakov (Infineon Technologies AG, Germany)

14:20 ***An X-Band Quasi-Circulator GaAs MMIC...342***

Laila F Marzall (University of Colorado Boulder, USA); Zoya Popović (University of Colorado at Boulder, USA)

This paper presents the design of an 8-12 GHz quasi-circulator fabricated in a 0.25-um GaAs pHEMT monolithic microwave integrated circuit (MMIC) process. The circuit consists of three Lange couplers which connect gates and drains of three equal gain-matched amplifiers. The coupling factor of the unequal-split Lange coupler is designed to achieve isolation higher than 20 dB over a 40% bandwidth, with a return loss of better than 10 dB and an insertion gain of 2.4 dB. The layout includes bias networks for the three amplifiers and occupies a 2.5 mm x 2.5 mm die. The compact quasi-circulator is intended for use in full-duplex front ends.

14:40 ***Thermal-aware GaN/Si MMIC design for space applications...346***

Chiara Ramella and Marco Pirola (Politecnico di Torino, Italy); Andrea Reale (Università degli Studi di Roma - Tor Vergata, Italy); Paolo Colantonio (University of Roma Tor Vergata, Italy); Vittorio Camarchia (Politecnico di Torino, Italy); Anna Piacibello and Rocco Giofrè (University of Roma Tor Vergata, Italy); Matthias Auf der Maur (University of Rome Tor Vergata, Italy); Mariarcangela Ramundo (Università degli Studi di Roma - Tor Vergata, Italy)

Thermal stress in microwave power devices is a major issue for space applications, with a detrimental impact on the operating life-time of MMICs on board satellites. To limit this, derating rules are applied to the maximum operating junction temperature, which however strongly limit the potential device performance when GaN/Si technology is employed. In this framework, classical power amplifier design paradigm must be reconsidered, moving to a thermal-aware design approach. To this aim, it is crucial to have access to highly reliable thermal models of the adopted devices. This work will show that, adopting a simplified but effective thermal model and proper design strategy, GaN/Si technology can be successfully adopted for space-compliant MMIC design up to Ka-band. In particular, the preliminary design of a 10W MMIC working in Ka-band at 36 GHz will be presented based on the 100nm gate-length GaN/Si HEMT process from OMMIC foundry.

15:00 ***A Novel Double Balanced Architecture with VSWR Immunity for High Efficiency Power Amplifier...352***

Geneviève Baudoin and Olivier Venard (ESYCOM - ESIEE, France); Kimon Vivien (ESIEE Paris, France)

In this paper a high efficiency power amplifier is presented with quasi VSWR immunity. It is based on a new, high efficiency architecture, the Load Modulated Balanced Amplifier. By using a balanced amplifier to generate the control signal, the overall circuit showed very high VSWR tolerance compared to classic designs. The circuit is currently under development in a single chip RFIC in CMOS and IPD technology.

15:20 ***18-24 GHz compact single stage amplifier with 13 ± 0.5 dB gain, OP3dBc of +19 dBm and 19% PAE for radar applications in Tower 180 nm***

CMOS...357

Samuel Jameson, Nadav Buadana, Eli Szulc, Avraham Sayag, Isaac Sarusi, Ofer Shaham and Amitay Wolfman (Rafael, Israel)

This paper proposes a modified differential cascode amplifier topology for mm-wave applications requiring wide-band amplification, flatness and compact integration area. The proposed topology was used to create a single stage power amplifier with +13 dB small-signal gain ±0.5 dB flatness in the K-band. The power amplifier load-pull and biasing were optimized to reach a maximum PAE around 3 dB compression to minimize AM-PM variation and maximize performance-to-reliability ratio in large phased array transmitters. At 3 dB compression, an output power of +19 dBm with a peak PAE of 19% was measured around 18 GHz. The circuit demonstrates one of the smallest core area (0.16 mm2) and excellent power density. The proposed topology presents currently a record small signal gain per stage for 180 nm CMOS. The presented amplifier topology can be used repetitively and reliably to create wide-band amplifiers with state-of-the-art gain and flatness.

15:40 ***Non-Linear Diode Rectifier Analysis for Multi-Tone Wireless Power Harvesting...362***

Ana Lopez Yela (Universidad Carlos III de Madrid, Spain); Alberto López Yela (University Carlos III of Madrid, Spain); Zoya Popović (University of Colorado at Boulder, USA); Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain)

This paper presents an analysis of the non-linear performance of a zero-bias Schottky diode under multi-tone excitation for wireless power harvesting applications. At low incident power levels, it has been shown that multi-tone inputs increase RF-DC conversion efficiency. Here we extend the theoretical analysis to include a more practical diode model which includes series resistance essential for determining efficiency. We show that the more complex theory approximates the real diode IV curve more accurately at low input power levels than previous models which neglect the series resistance.

RD2: Tutorial: Millimeter-wave radar systems

Room: Grand C

Chair: Mario Pauli (Karlsruhe Institute of Technology, Germany)

14:20 ***Millimeter-wave radar systems...N/A***

Vadim Issakov (Infineon Technologies AG, Germany)

Recent advances of the silicon-based semiconductor processes and packaging technologies have accelerated the implementation of radar sensors for numerous mass-volume applications at mm-wave frequencies. This talk will start with the basic introduction of continuous-wave (CW) and pulsed radar systems. We discuss briefly the frequency regulations for automotive and consumer radar applications. Then we focus only on CW and FMCW systems and consider range, velocity and angular resolution. We discuss how to derive a specification of the radar system based on the specific radar application scenario, as e.g. link budget calculation, frequency chirp, dimensioning of filters and VGA in the analog baseband, choosing sampling rate and resolution of the ADC. Next, we discuss the impact of phase noise on radar systems, as e.g. range correlation effect. Further, we discuss the radar signal processing, range-Doppler map and detection of multiple targets. Finally, we discuss advanced topics as noise floor degradation by non-ideal mixing and TX to RX spillover cancellation and show integrated radar system examples.

T5: Design of Broadband, Linear, and High-Efficiency Mm-Wave Power Amplifiers

Room 3

14:20 ***Design of Broadband, Linear, and High-Efficiency Mm-Wave Power Amplifiers...N/A***

Hua Wang (Georgia Institute of Technology, USA)

The abstract will be added soon. This is a tutorial about PA by Prof. Hua Wang.

PT1: Packaging & Thermal Management 1

Room 5

Chairs: Yoav Peles (University of Central Florida, USA), Gennady Ziskind (Ben-Gurion University of the Negev, Israel)

14:20 ***Thermal Challenges for Future Military Platforms...N/A***

Mark Spector (ONR, USA)

To be defined soon

14:50 ***Modeling the Thermal Performance of a Packaged MEMS Thermal Sensor at Wide Pressure Range for IoT Applications...367***

Moshe Avraham, Dima Shlenkevitch, Sara Stolyarova, Tanya Blank, Yael Nemirovsky and Ayal Shabtay (Technion, Israel)

This paper focuses on the thermal performance of a wafer level packaged MEMS thermal sensor, where the pressure varies between deep vacuum (0.1 Pa) and atmospheric pressure. The simulations are based on commercial software and are corroborated by modeling and measurements. There is a good agreement between the measured experimental data for the thermal time constant and the modeling and simulations.

15:10 ***PCB Surface Finish Impact to Losses at High Frequencies...371***

Alexander Ippich (Isola, Germany)

In RF/microwave applications, most critical signals are routed as surface microstrip transmission lines without soldermask coverage. The lack of soldermask on the traces will result in the metal surface finish deposited on the traces. Especially the common ENIG surface finish is causing excessive losses. To determine the impact of the surface finishes on the insertion losses, a DOE with six different surface finish chemistries was performed. Microstrip transmission lines on an ultra-low loss laminate were produced and S-parameters determined. Variation in-between samples with the same surface finish and between the surface finishes were evaluated, allowing to set-up a ranking of the surface finish processes.

15:30 ***Thermal Aspects of High Power Microelectronics Systems Implementation in Aviation Applications...NA***

David Ratner (Rafael, Germany)

High power temperature-sensitive microelectronics and RF systems combined with extreme environmental conditions typical to aviation applications present a significant challenge in meeting component temperature requirements. This presentation shows an engineering solution for an aircraft-deployed RF System. Work covers both flow and heat transfer simulations and experiments. The system thermal design includes: - High altitude and velocity cooling fin design. - Thermo-electric Coolers. - Component uprating. - Complicated thermal interface material (TIM) design

15:50 ***GlassTomer™ - Innovative Hermetic Seal for Lightweight Connectors...N/A***

Lior Gorstein (Hermetron, Israel)

Hermetron presents an innovative Lightweight alternative to glass-sealed hermetic connectors for use in weight-sensitive applications where a high level of sealing is required. (Better Than 1×10-8 cc He/sec).When the mission demands hermeticity, and the project demands can't compromise the weight and electrical resistance of steel or Kovar, GlassTomer is Hermetron's innovative sealing technique that is similar to glass-seal in its hermetic capabilities. A lightweight Aluminum connector shell package, and Beryllium-cupper low contact resistance AND mission-critical durability. Unlike static epoxy potting, GlassTomer sealing is a dynamic adhesive material Immune to thermal cycles and mechanical shocks Meets NASA Out-gassing Copper alloy contacts Testing and validation: • 100 hours of thermal shocks • More than 1000 hours of thermal aging. • Insulation resistance: >10,000 mega-ohm @ 500 VDC • Operating Temperature -55°c to +225°c continuous, • 335°c intermittent Robust design demonstrated for over 5 years and thousands of parts are used in aero-space projects with zero failure.

AP5: Antenna Analysis in Time Domain and Beamforming

Room: Royal H

Chairs: Amedeo Capozzoli (Università di Napoli Federico II, Italy), Paolo Rocca (University of Trento, Italy)

14:20 ***Space-Time Coding through Time-Modulated Arrays - State-of-the-Art and Recent Trend/Advances...375***

Paolo Rocca (University of Trento, Italy); Lorenzo Poli (ELEDIA Research Center, University of Trento, Italy); Shiwen Yang (University of Electronic Science and Technology of China (UESTC), China)

This paper presents some recent advances in the synthesis of time-modulated arrays (TMA), focusing on the suitable optimization of the pulse sequences controlling the element excitations of the array for achieving constant instantaneous directivity. In particular, the synthesis of TMA taking into account the non-ideal switches behavior and the electromagnetic coupling phenomena between real elements have been proposed as well as a study of the constant-directivity TMA used for enabling directional modulation for physical layer secure communications, by exploiting the replicas of the signal generated in the sideband radiation.

14:50 ***Temporal Switching for Wideband Impedance Matching and Non-reciprocity...N/A***

Yakir Hadad (Tel-Aviv University, USA); Amir Shlivinski (Ben-Gurion University of the Negev, Israel)

Passivity, Linearity, and Time-Invariance are three assumptions on a system that undergraduate students of engineering are repeatedly use. In fact, this family of systems are analytically trackable and thus physically insightful, and moreover many practical systems can actually be approximated as such. However, systems that possess these characteristics are also bounded by some fundamental limits. Such a limit was introduced in the 40's by H. W. Bode and R. M. Fano, two giants of network and system theory. Their bound, the so called Bode-Fano criterion, imposes a stringent tradeoff in wave-engineering between the impedance matching bandwidth and its efficiency. In our work we revoke the time-invariance assumption and demonstrate how by using temporally-switched transmission network together with standard optimization tools it is possible to significantly overcome the Bode-Fano bound, and obtain a wideband and efficient impedance matching for short-time pulses. Moreover, by introducing an additional effect of synthetic motion we show that UWB magnet-less non-reciprocity can also be achieved. Our work opens venues in wideband communication technology, for medical imaging, compact antenna systems, wideband cloaking and absorbers, and it is applicable for electromagnetic and acoustic wave systems.

15:10 ***A New Analytical and Numerical Method for Describing the Response of a Linear Antenna for Pulse Excitation Submission...379***

Józef Małecki (Polish Naval Academy, Poland); Anna Witenberg (UTP University of Science and Technology, Poland); Maciej Walkowiak (University of Science and Technology in Bydgoszcz, Poland)

The paper proposes a hybrid method based on a combined numerical and analytical description of the linear antenna response to Gaussian pulse excitation. Its advantage is to avoid losing the stability of calculations while solving the electric field integral equation in time domain. In the numerical part of the method, the MOT algorithm was used; in the analytical part discrete mean-square approximation with new modified spherical Bessel functions of the first kind as a base was used. This allowed us to calculate the approximating (and extrapolating) functions of small orders.

15:30 ***Echo generation by SVO...383***

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

We deal with an approach, based on the Singular Value Optimization (SVO) technique, for the synthesis of arraybased generators of near-field echoes. The approach selects the grid wherein enforcing the design specifications and the radiator locations to control the ill-conditioning associated to the determination of the array excitation coefficients. Following the SVO optimization, the array coefficients are determined by a Singular Value Decomposition (SVD). Numerical results are provided for the synthesis of the near-field scattered by a perfectly conducting sphere illuminated by an elementary dipole.

15:50 ***SVO optimality in Near-Field Antenna Characterization...387***

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

We show that the sampling approach provided by the Singular Value Optimization (SVO) technique is "optimal" in the sense that it leads to the use of elementary antennas having the same performance of "virtual" receiving antennas provided by the application of the Singular Value Decomposition (SVD) approach. The discussion is led in a 2D, scalar setting. The theoretical arguments are supported by numerical results referring to a full 3D Near-Field/Far-Field (NFFF) transformation problem.

BM3: Cardiac and Respiratory Systems

Room: Royal I

Chairs: Ramez Daniel (Israel Institute of Technology, Israel), Amir Landesberg (Technion, Israel)

14:20 ***Detection of Peripheral Artery Stenosis Utilizing Wavelet Coherence Analysis...391***

Amit Livneh (Technion-Israel Institute of Technology, Israel)

The peripheral arterial disease (PAD) pandemic affects over 200 million patients and is associated with a high risk of cardiovascular morbidity and mortality. The current screening method for PAD measures the ankle to brachial systolic pressure ratio and suffers from severe limitations. We present a novel modality for non-invasive monitoring of extremity perfusion, which employs miniature-sensors and impedance electrodes. Our novel indices of the peripheral perfusion wave dynamics were derived in the time and time-frequency domains over multiple cardiac cycles. The novel modality detected arterial-stenosis, induced by cuff compression, even with undetectable changes in the pressure.

14:50 ***Early Diagnosis of Internal Hemorrhage via Deep Neural Network Inference of Radio Signals...396***

Shye Shapira (InnerSight, Israel); Ofir Tal (Innersight, Israel)

A Compact Automatic Diagnostic system for internal Hemorrhage is described. Utilizing harmless radio frequency sensing and Deep Neural Network Inference a sensitivity of 92.9% in detection of abdominal Internal Hemhorrage is demonstrated.

15:10 ***Development of hardware-software microscopy complex for the study of buccal epithelial cells...400***

Anastasiya Rumyantseva, George Kolokolnikov, Andrey Samorodov and Alexander Volkov (Bauman Moscow State Technical University, Russia)

The paper is devoted to the development of hardware-software microscopy complex for the study of buccal epithelial cells. The goal and objectives of the work were determined, and the approach to achieve them was chosen. A medical problem was formulated and the biophysical bases for the study of the electrokinetic properties of buccal epithelial cells were described. System-wide solutions were proposed in the form of a developed biotechnical system scheme. A structural-functional model of the system processes was developed in accordance with the IDEF0-notation. The methodology of buccal epithelial cells exploration was proposed. The hardware implementation and the developed specialized software used in the research were described. Further directions of project development were proposed.

15:30 ***Mathematical modeling of varicose veins ultrasound heating...406***

Anna Borde and Gennady Savrasov (Bauman Moscow State Technical University (BMSTU), Russia)

During the last decade less invasive endovenous methods of treatment of lower limb varicose veins (LLVV) have obtained widespread appreciation. Nevertheless, the problem of improving their long-term results is still actual. The aim of this study is investigation of the biothermomechanical response of the venous wall to the low-frequency ultrasound exposure, which is an advanced method in the treatment of LLVV. The model designed to analyze frequency range of the ultrasound instrument and the different values of its pullback velocity. According to the simulation results, the frequency range, in which necrotic changes of the venous wall can be caused was determined. The dependencies of the venous wall collagen denaturation time on the temperature and pullback velocity of the ultrasound instrument were obtained. After the developed model is supplemented with temperature dependencies of the physical properties of the venous wall, these results can be used to form requirements for ultrasound treatment modes for lower limb varicose veins.

15:50 ***Novel Electronic Devices for the Management of Heart Failure...N/A***

Amir Landesberg (Technion, Israel)

Not Available

CS4: Future of Communications

Irving Kalet

Room: Royal J

Chair: Irving Kalet (Technion, Israel)

14:20 ***Gaussian Diamond Primitive Relay with Oblivious Processing...411***

Asif Katz (Technion - Israel Institute of Technology, Israel); Michael Peleg (Rafael ltd. & Technion - Israel Institute of Technology, Electrical Engineering, Israel); Shlomo (Shitz) Shamai (The Technion, Israel)

We examine the filtered Gaussian primitive diamond relay channel, where the signal received at both relays is described by symmetric filtered Gaussian channels, and where the relays are connected to the destination via noiseless fronthaul links of a given capacity. The frequency response of the filters are available to all system components. We characterize analytically the Gaussian input frequency power distribution that maximizes the optimal information rate of the oblivious (code independent) relay operation achieved by joint decompression-decoding (or optimized Wyner- Ziv) procedure. We investigated and derived the optimal frequency-dependent allocation of power and bitrate for a pair of oblivious relays operating over the AWGN frequency-dependent channel and using classical Gaussian codes.

14:40 ***Millimeter and Tera-Hertz Waves - New Spectrum for Wireless Communications...N/A***

Yosef Pinhasi (Ariel University, Israel)

The deficiency of wide free bands in the 'conventional' spectrum allocated for wireless communications, demands identification of new frequency regions above 30GHz. This extremely high frequencies (EHF)range, which is also known as the millimeter wavelengths (MMW) band, is still not massively used for wireless communication applications.

15:00 ***Polar Codes: Overview, Recent Research and Challenges...N/A***

Yejun He (Shenzhen University, China)

Polar code is the only channel coding method that can reach the Shannon limit in theory so far. The construction of polar code is based on the phenomenon of channel polarization. In this talk, we firstly start with an overview of channel coding. Then we analyze the channel polarization phenomena and introduce recent advances of polar codes. How to construct and decode is very important for improving the performance of polar codes. We will introduce our work in construction and decoding algorithm for polar codes. Finally, we discuss the challenges of polar codes.

15:20 ***A Look at 6G...N/A***

Irving Kalet (Ariel University)

The cellular world is already discussing the standards and challenges for 6G, even though the standards will only be finalized in another ten years. In this talk we will look at the present discussion of the radio interface standards, and ask the question as to whether OFDM will be the modulation for 6G, as well.

Tuesday, November 5 15:30 - 16:10

IP: Intellectual property

Marc Weinstein

Room 4

15:30 ***Using intellectual property to protect innovations in a global marketplace...N/A***

Marc Weinstein (Xsensus Intellectual Property LLP, USA)

Any industry seeking success in the global marketplace must make skillful use of patents, trade secrets, and employee contracts to ensure protection of its technical know-how and innovation. This talk offers insights and examples of how high-tech companies in Israel and elsewhere can realize this protection and maximize their business advantage. The techniques include close attention to patent law in different countries, cross-licensing agreements, and effective use of legal remedies. The speaker has extensive experience in international patent licensing and litigation.

Tuesday, November 5 16:20 - 18:00

IF: Interactive Forum

Room: Grand A

Chairs: Aleksey Dyskin (Technion - Israel Institute of Technology, Israel), Reuven Shavit (Ben-Gurion University, Israel)

A System Stability Analysis for a Time-Delayed Four Meander Line Antenna Legs Birdcage for Helicon Excitation with Titanium Alloy and Copper Legs...417

Ofer Aluf (Netanya, Israel)

A four meander line antenna legs birdcage for helicon excitation with titanium alloy and copper legs is used in many applications. Helicon waves are electromagnetic waves which propagate in magnetized plasma. An approach for helicon plasma source improvement consists in optimizing helicon wave excitation by means of specific antenna designs. The antenna is composed of N1 identical meander line antenna legs equally distributed on a cylinder of radius Rc. We consider an N1=4 design. Due to the RF antenna leg parasitic effect we get each leg's current with delay τ_k (k is a leg number index, k=1,…,4). For simplicity, we assume all time delays are equal, $\tau_k=\tau$ for k=1,2,3,4. We present a practical guide which combines graphical information with theoretical analysis to effectively study the local stability of models involving delay dependent parameters. The stability of a given steady state is determined by the graphs of some function of τ.

Improved THz Reception by Non-Conventional Structure of Planar Dipole Antenna with Superconducting Josephson Junction Detector...423

Eldad Holdengreber, Moshe Mizrahi, Vitaly Khavkin, Shmuel E. Schacham and Eliyahu Farber (Ariel University, Israel)

Intensity and frequency of THz RF radiation are easily derived from superconducting Josephson junctions detectors I-V characteristics. The RF radiation generates current steps, correlated to intensity. The voltage at the steps renders accurately the RF frequency. DC measurements simplify significantly the detection systems. Implementing junctions in high temperature superconductors, requiring liquid nitrogen cooling only, reduces drastically operating complexity and cost. System efficiency is highly sensitive to impedance mismatch between antenna and low impedance junction. We propose improved planar dipole antenna structure, where the junction is placed between the ends of two strips, removed from the dipole. Theoretical RF analysis of the influence of junction parameters on input impedance was carried out. Extensive simulations of detection system were performed. High impedance matching was obtained for 195 to 215GHz, show high directivity, with radiation gain of 5.22dB and low return losses of 35dB.

Computationally Efficient Electrodynamic Method for Analysis of Microlenses...427

Igor V Donets and Alexander M. Lerer (Southern Federal University, Russia); Li Zimeng (Guangzhou Compass Antenna Design and Research, China); Svetlana Tsvetkovskaya (Don State Technical University, Russia); Michael Mazuritsky (Southern Federal University, Russia)

The efficient electrodynamics method of analysis of micro lenses with size measured by several or tens of wavelengths are developed. For the analysis of lenses in the specified range, it is proposed to use a high-frequency integral equation with the representation of the green function in both spherical and cylindrical representations. The focusing properties of micro lenses of different profiles are investigated.

Dual-Wideband Patch-Slot Loop Textile Antenna for WBAN/WiFi/LTE Applications...431

Kuo-Sheng Chin (Chang Gung University, Taiwan); Eric S. Li (National Taipei University of Technology, Taiwan); Roger Lu (National Chung-Shan Institute of Science and Technology, Taiwan); Hung-Wei Lo and Yu-You Lin (Chang Gung University, Taiwan)

This work presents a textile antenna with dual-wideband performance for wearable wireless communications. The patch-slot loop structure was developed to obtain two wide operating bands, in which a slot loop was cut on the ground plane underneath the patch. The top patch acts as a wideband radiating element at the upper operating band, while the slot loop is fed by the top patch to excite a wideband resonance at the lower operating band. A copper-plated polyester fabric was used for fabricating antenna radiator and ground plane. An insulating neoprene fabric with a permittivity of 1.5 was used for preparing the substrates. The proposed antenna can achieve gains of 4.21/6.45 dBi at 2.58/5.34 GHz with wide bandwidths of 15.9/ 11.4 %, respectively.

Effectiveness of Various 5G Modulation Techniques in Different Weather Conditions...435

Yosef Golovachev (Ariel University & Jerusalem College of Technology, Israel); Aaron Mazor (Jerusalem College of Technology, Israel); Gad A. Pinhasi and Yosef Pinhasi (Ariel University, Israel)

Different modulation techniques have been proposed for usage in 5G systems in order to provide greater flexibility and thereby increase transmission efficiency. One of the most substantial option was the allocation of bandwidth in the Extremely High Frequency (EHF) range, 30-300 GHz, that can lead to the development of practical consumer applications of millimeter wave (MMW) technologies. The transmitting at higher frequencies communications have many advantages, however only recently this opportunity is being proposed for 5th Generation Communications due to atmospheric propagation issues. In general, atmospheric effects are due to absorption and dispersion phenomena. Due to small wavelengths, MMW propagation is significantly affected by weather conditions, such as rain, fog, air pressure, temperature, and relative humidity. In order to simulate the effects of atmospheric conditions on the signal, a Baseband Equivalent Channel Model is developed. This channel model is applied to the transmitted modulated signal. Finally, received signal is demodulated through an inverse process to that experienced by the signal at the transmitter, at which point various signal characteristics such as the Bit Error Rate (BER) and received constellation are used to determine the atmospheric channel's effects on the final transmission.

Small Antenna for Small Spacecraft...N/A

Ely Levine (AFEKA, Academic College of Engineering, Israel); Haim Matzner (HIT-Holon Institute of Technology, Israel)

we propose and compare three types of isotropic antennas that can be integrated onto a spacecraft. (a) monopole antenna with multiple arms. (b) Quad Helix antenna. (c) array of four microstrip antennas mounted on a pyramid. A, optimal choice for small spacecraft would be the microstrip array with circular polarization. This solution provides better mechanical strength and endurance with gain 2+/-1 dBic and axial ratio 1-2 dB.

Observation of photonic Jackiw-Rebbi states in chains of all-dielectric bianisotropic particles...438

Dmitry V. Zhirihin (ITMO University, Russia); Alexey Gorlach (Belarusian State University, Belarus); Alexey P. Slobozhanyuk (ITMO University & Australian National University, Russia); Alexander Khanikaev (The City College of New York, USA); Maxim Gorlach (ITMO University, Russia)

In this paper we study theoretically and experimentally chains of all-dielectric bianisotropic particles. We show that photonic analogues of Jackiw-Rebbi states emerge at the interface between the domains with the opposite sign of bianisotropy parameter. Using near-field measurements, we perform proof-of-principle experimental demonstration of the interface states and reveal field localization at the domain wall in microwave frequency range.

A Plasmonic Behavior of Slotted Nano-Structured Huygens Metasurface on Silicon for Photovoltaic Applications...N/A

Êmille Lorrane Patrício (University of Campinas, Brazil); Luiz C. Kretly (Unicamp, Brazil)

The technology investigated is characterized as Huygens metasurface. Also, being nano-structured and applied on photovoltaic environment. Fabricated, analyzed and to be characterized to prove the ability to manipulate the THz radiation. The composition of this metasurface involves cylindrical slots on the silicon metasurface. Designed to operate in the optical range, whose behavior began on 0 THz to 200 THz. Additionally, the slot structure is 0.03 um deep with a periodicity of 0.2 or 0.4 um. While, the Huygens metasurface is tested on commercial simulators using waveguide ports. Likewise, it has been manufactured by FIB-Focused Ion Beam equipment. Demonstrated that simple slotted metasurface can interact without the need of active metasurface as proposed. Correspondingly, the device here proposed do not use polymeric film but only bare silicon with a soft doping. Moreover, it pretends to extend the photovoltaic system lifetime and efficiency. The physical characterization and measurements are ongoing. Matching that, if you consider parameters such as high-efficiency, long-life and

full-colour devices, a periodic nano-structure is likely to be major for future works. The sizeable propriety of the structure brings the possibility of manipulation of THz radiation as showed along this work. An right shift of the beginning of the bandwidths and an shift value in the bandwidth broadening.

The Use of metamaterial Tripolar Array for UWB Antenna Optimization...N/A

Humberto Xavier de Araujo (Universidade Federal do Tocantins, Brazil); Geyse da Silva and Rhayssa Oliveira (UFT, Brazil); Carlos Eduardo Capovilla (UFABC, Brazil); Luiz C. Kretly (Unicamp, Brazil)

In this paper, the tripolar array metamaterial technology is applied into an UWB antenna in order to optimize its performance. Four antennas are proposed using the metamaterial tripolar array, in order to achieve better gain, bandwidth and frequency resonance when compare to a conventional UWB antenna. The main idea is to improve its performance without increase its dimensions which could compromise their application in telecommunications systems especially mobile devices. From the modifications made it was possible to improve antenna efficiency, reducing the return loss in up 76%.

Terahertz Antenna for 5G Cellular Communication Systems: A Holistic Review...440

Uri Nissanov (South of Africa)

The next cellular communication in the 5G and beyond can be in the sub-Terahertz (THz) band, i.e. (100-350) GHz, because data rate of (20-100) Gbps is needed. Following atmospheric path loss in THz frequency band, which can reach more than 100 dB / km, there is a need to operate in frequency windows below 1 THz, where the atmospheric attenuation is relatively low, and the high-gain antennas that allow the propagation of the signal beyond 100 meters, because of lack of solid-state communication sources with a power of over 10 mW, as well as wide bandwidth (BW) antennas that will enable data rates of at least 20 Gbps. In this technical review, we explain what the demands and the challenges of antennas at 5G and are beyond: how to improve the gain and BW of the antennas simultaneously, what is the minimum gain and BW of the antennas.

Realization of Novel Digitization Circuits in SDRs and CRs...446

Yefim S. Poberezhskiy (Consultant (Communications & Signal Processing), USA); Gennady Y. Poberezhskiy (Raytheon Space and Airborne Systems, USA)

Algorithms and circuits, which follow from the sampling theorem's direct, indirect, and hybrid interpretations, are equally optimal in the ideal case, but perform differently in real-world conditions. Initially, only sampling circuits based on the indirect interpretation were feasible. They are still widely used in software-defined and cognitive radios (SDRs and CRs). More advanced multichannel digitization circuits, supported by modern IC technology and based on the hybrid and direct interpretations, radically improve parameters of SDRs and CRs. The choice of correlator-like or matched-filter-like channels for these circuits depends on the specific application of SDRs and CRs as well as on available IC technology.

Novel Conception of Loss Tangent Media Measurement with Laser-Driven Gallium Arsenide Switches...452

Maxim Kulygin (Institute of Applied Physics, Russia)

A conception of using laser-driven resonator cavity switches with an active element of semiconductor to measure the semiconductor's loss tangent being unknown is proposed and discussed. A sample calculation for an existent gallium arsenide-based prototype for the frequencies around 300 GHz has demonstrated an unambiguous determination of the loss tangent in the range of at least four orders and two methods. Such a redundancy helps to come over a fabrication imprecision for each prototype and ensure high precision of measurements.

A 70W High Efficiency Power Amplifier for Base Station Applications...455

Meir Alon and Sigmond Singer (Tel Aviv University, Israel)

in this paper a 70W high efficiency power amplifier in a range of 2Ghz- 3.6Ghz bandwidth with 55-65% efficiency is introduced, applicable for base station infrastructure. The design makes harmonic engineering till the 3rd harmonic at the output, in order to reach the highest efficiency. The amplifier is tested with a 40Mhz LTE signal with DPD implementation.

UWB-Based Positioning System for Supporting Lightweight Handheld Ground-Penetrating Radar...459

Piotr Kaniewski, Tomasz Kraszewski and Przemyslaw Pasek (Military University of Technology, Poland)

The paper presents a concept of a high-accuracy positioning system, using ultrawideband (UWB) radio modules. The system is dedicated for supporting operation of a handheld ground-penetrating radar (GPR), as the use of information about the antenna coordinates at the moments of scanning enables correction of the radar signals and facilitates creation of high-resolution subsurface images. The presented system is self-contained and easy-deployable; it has centimeter-level accuracy and provides positioning data with high repeatability. The system's structure, mathematical model, positioning algorithm and chosen simulation results are presented in the paper.

Search of Binary Codes Compressed to Several Sub-pulses...N/A

Hiroshi Takase and Masanori Shinriki (Nippon Institute of Technology, Japan)

Binary codes, which are compressed to a signal with a width of several sub-pulses and small sidelobes, are searched using a genetic algorithm because they cannot be found by exhaustive search. We searched for codes lengths from 61 to 66 using Genetic Algorithm. We found new codes with longer code length and that the peak-sidelobe to peak-mainlobe ratios are smaller than such conventional codes as optimum binary codes. We also indicate the Doppler characteristic of the codes.

Influence of Electrical Properties of Media on Reconstruction of Microwave Holograms Recorded by Subsurface Radar...463

Vladimir Razevig and Sergey Ivashov (Bauman Moscow State Technical University, Russia); Margarita Chizh (Bauman Moscow State Technical University & Remote Sensing Laboratory, Russia); Andrey Zhuravlev (Bauman Moscow State Technical University, Russia); Lorenzo Capineri (University of Florence, Italy)

The paper studies the influence of electrical properties of homogeneous media on reconstruction of microwave holograms recorded by a subsurface radar. The goal is to estimate the influence of relative permittivity and the influence of attenuation coefficient separately. The main study was performed by numerical simulation using computational electromagnetics software Altair FEKO. It was shown that the main factor affecting the shape of a hologram is relative permittivity of the medium that greatly affects the antenna pattern. To verify the model, the experiments were carried out with subsurface holographic radar of the RASCAN type, emitting a single frequency continuous 6.4 GHz signal. The experimental results confirm the validity of the numerical model and the conclusion.

Monolithic High Power 300 Watt, S-Band, HMIC PIN Diode Limiter...468

Timothy Boles, James Brogle, Joseph Bukowski and Paolo Brosera (MACOM Technology Solutions, USA)

A monolithic multi-stage high power silicon/HMIC PIN diode limiter that covers the full range of UHF to S-Band frequencies has been designed that is capable of handling up to 300 watts CW of incident RF power. This monolithic MMIC limiter approach has been enabled by recent improvements to MACOM's state-of-the-art HMIC PIN diode technology. This MMIC design will be able to produce superior RF performance and power handling when compared to present hybrid assembled limiters that are based upon chip and wire integration of discrete PIN diodes but having a dramatic reduction the overall footprint and a significant reduction in device cost.

Quasi-Differential Operation of Capacitive Tuners for Aperture Tuning Applications...473

Oguzhan Oezdamar (University of Erlangen-Nuremberg, Germany); Valentyn Solomko (Infineon Technologies, Germany); Robert Weigel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Amelie Hagelauer (University of Bayreuth, Germany); Anthony Thomas (Infineon Technologies, Germany)

A method of operating a switch-based series capacitive tuner in quasi-differential mode is proposed. The method suggests to split the applied RF voltage between the terminals of the tuner such that the terminals see the out-of-phase voltage waveforms with reduced amplitudes. The proposed approach allows minimizing power losses in the parasitic shunt resistive elements of the capacitive tuner. The same approach may be applied to antenna tuning switches as well. The method is evaluated on a capacitive tuner integrated circuit fabricated in bulk-CMOS RF-switch technology. The network based on the prototype operating in quasi-differential mode demonstrated a potential to reduce power losses by up to 15% when operating

at high-ohmic aperture tuning plane.

An 8 Way Power Combined 28GHz Direct Downconversion Receiver for 5G RF Beamformers...479

Ritabrata Bhattacharya (Cadence Design Systems, India); Alex Tiker (Cadence Design Systems, Israel); Ashish Gupta and Vikas Aggarwal (Cadence Design Systems, India); Taranjit Kukal (Cadence, India); Sankaran Aniruddhan (Indian Institute of Technology Madras, India)

A passive eight-way power combined 28GHz mm-wave Gilbert cell I-Q Mixer in a 45nm bulk CMOS process is reported in this work for 5G RF beamformers. The 8:1 novel lumped quarter wave combiner/splitter utilizes transformer coupling to achieve a post layout efficiency of 67%, with a 2X reduction in area when compared to a spiral inductor-only implementation. With an isolation between ports greater than -22 dB, the amplitude and phase mismatch of the power combiner are kept within 0.3dB and 3 degrees respectively. Post-layout EM simulations of the I-Q mixer utilizing a current bleed technique predict a gain of 9dB, an OIP3 of +9dBm and a noise figure of 9.9dB at a power consumption of 17mW in an active area of only 0.39mm2. The I-Q mismatch of the receiver is 0.5 dB in amplitude and 0.5 degree in phase, leading to an RSB <-40dBc. To ensure compact realization, two key layout improvements over a conventional mm-wave Gilbert cell are also discussed.

Circuit Model of Choke Coils for Approximating Frequency-Dependent Winding Losses...483

Andreas Marquardt (Sumida Components GmbH, Germany); Michael Schmidhuber (SUMIDA Components & Modules GmbH, Germany); Guido Dietl (University of Applied Sciences Landshut, Germany)

Both windings and magnetic material cause losses in choke coils. For the efficient design of choke coils, a model of these losses is required where they are considered separately. In this paper, we focus solely on the winding loss. There are a number of methods to determine the winding loss. Most of them are based on numerical methods for computing electromagnetic fields like, e.g., the finite element method (FEM). Unfortunately, these methods are computationally expensive and have significant limitations. For instance, it is not feasible to consider special cases like, e.g., litz wires or complicated winding or core geometries. This paper introduces a computationally efficient and more universal approach for determining winding losses. The presented method is based on firstly measuring the frequency-dependent resistance of the winding, followed by a numerical approximation of this resistance via a network of passive components based on the Levenberg-Marquardt optimization method. Finally, the winding losses of a choke coil can be computed under real operating conditions by investigating the resulting network using a conventional circuit simulator. Simulation results of a choke coil with a flat wire show a high accuracy when compared to three-dimensional (3D) FEM simulations despite of its tremendously smaller computational complexity.

An analysis of the power balance in systems described by S parameters...489

Vladimir Vulfin (Ben-Gurion University of the Negev, Israel); Nastya Verhovsky (Electromagnetics Infinity, Israel); Shai Sayfan-Altman (ANSYS inc., Israel); Reuven Ianconescu (Shenkar College of Engineering and Design, Israel)

The interpretation of the S parameters concerning power balance is often misunderstood. This work analyzes the power balance in systems described by S parameters and defines more accurate criteria for examining this property.

U-Slot Dual-band Frequency Reconfigurable Patch Antenna Tuned With Commercial Ferroelectric BST capacitors...492

Ts Kalkur (University of Colorado, Colorado Springs, USA)

A U-slot dual-band frequency reconfigurable patch antenna is presented in this paper. The resonant frequencies of the antenna before loading with varactors are 1.3 GHz and 2.4 GHz. The tunability is achieved using p-n varactors and ferroelectric tunable capacitors. It is found that individual tuning for both frequency bands is possible depending on the capacitor position. The maximum tuning range achieved for the first band is 600 MHz and the same for the second band is 422 MHz. The minimum and maximum gain values for the lower band are found to be 4.25 dBi and 4.95 dBi, respectively. Similarly, for the upper band, those values are obtained as 6.77 dBi and 7 dBi, respectively.

Low Phase Noise NLTL Comb Generator...N/A

Chandu Sirimalla and Jack Redus (Macom, USA); Paolo Brosera (MACOM Technology Solutions, USA)

This paper presents a low phase noise comb generator based on a nonlinear transmission line (NLTL) design. The comb generator is MACOM's MLPNC-7102S1SMT580 with output frequencies up to 12 GHz. Output power of harmonics up to 12 GHz and phase noise results at 12 GHz are presented.

Study of a Method for Effective Noise Suppression in Passive Personnel Screening Systems...498

Andrey Zhuravlev (Bauman Moscow State Technical University, Russia)

The paper discusses approaches to increase the sensitivity of passive personnel screening systems by integrating sequential frames with a moving subject. Several state-of-the-art methods of computer vision are considered for this purpose, which can be used to track moving subjects even on very different frames. The results of experiments using the computer vision method DensePose, based on the use of artificial neural networks, are presented. Using DensePose, the segmentation of a moving subject and textural UV-coordinates for the surface model of the human body are found on frames, which are used in the described frame-by-frame integration method. Considering obtained results, the shortcomings of the proposed frame integration method are identified and listed. The directions of further research are suggested.

Spurious Detection and Cancellation Method for Millimeter Wave Heterodyne Transceiver Architecture...504

Zhou Du and Kimmo Aronkytö (Nokia Bell Labs, Finland)

A simple detecting and controlling circuit to measure and cancel the spurious emission of the millimeter wave heterodyne transceiver architecture is presented. In Time Division Duplex system, the spurious detection and cancellation operate in the receive time frame to avoid the interference in transmission. The test setup along with the exemplary algorithm for adjusting the parameters have been built and demonstrated using commercial-off-the-shelf components. The LO leakage has been reduced by 18.56 dB and 28.61 dB in 28 GHz and 39 GHz bands respectively. The proposed method enables the broadband tunable transceiver designs for the use cases with less stringent emission requirements.

Waveguide Excitation Using On-Chip Antenna for Wireline Data Links...509

Mukul Mishra (University of Texas at Dalas, USA); Neha Vijayakumar, Rashaunda Henderson, Het Trivedi, Ibunkunoluwa Momson and Michael Gomez (University of Texas at Dallas, USA); Nafiseh Aflakian (Southern Methodist University, USA); Zhe Chen (University of Texas at Dallas, USA); Kenneth O (The University of Texas at Dallas, USA); Duncan MacFarlane (Southern Methodist University, USA)

Wireline communication systems using millimeter-wave CMOS transceivers can benefit from high data rates when multiple channels are aggregated. The individual channels can be combined to provide rates approaching that of optoelectronic systems without the transition loss. This paper presents the excitation of a wideband waveguide using a dual-band dipole antenna fabricated in 65 nm CMOS technology for use in a wireline system. The on-chip dipole is designed for 180 and 315 GHz and implemented in a cross-configuration to provide horizontal and vertical polarization. The paper presents the simulation results for the dipole antenna and the waveguide excitation using the antenna.

Optical Pumping of Graphene-Based Heterostructures with Black-Arsenic-Phosphorus Absorbing-Cooling Layer for Terahertz Lasing...513

Maxim Ryzhii (University of Aizu, Japan); Victor Ryzhii and Taiichi Otsuji (Tohoku University, Japan); Vladimir Mitin (University at Buffalo, USA); Michael Shur (Rensselaer Polytechnic Institute, USA)

We evaluate the optical pumping efficiency of the graphene-layer (GL) heterostructures intended for the terahertz (THz) lasing using the interband transitions in the GL. The pumping of such heterostructures by near- or mid-infrared (NIR or MIR) radiation leads to the creation of a substantially hot two-dimensional electron-hole plasma (2D-EHP) in the GL. This hampers the interband population inversion in the 2D-EHP and can suppress the THz lasing. To prevent the 2D-EHP overheating, we propose to use the NIR/MIR radiation pumping of the GL through an sufficiently thick layer absorbing the this radiation. This layer with sufficiently small energy gap enables an increase in the quantum efficiency of the pumping accompanied by a strong cooling of the electron-hole pairs injected into the GL. As shown, the absorption layers made of black-arsenic-phosphorus can be fairly efficient if their energy gap is smaller than the optical phonon energy in the GL.

Catalytic Gas Sensor Based on Micro Machined CMOS Transistor...517

Dima Shlenkevitch, Moshe Avraham, Sara Stolyarova and Tanya Blank (Technion, Israel); Yael Nemirovsky (Technion_Israel institute of Technology, Israel)

A new generation of gas sensors based on a suspended thermal transistor MOS (TMOS), fabricated in standard CMOS-SOI process, released by post-etching, has been recently developed and dubbed GMOS. The GMOS is a catalytic gas sensor (Pellistor-like), and as such detects combustible gases in air. The sensors and read-out are processed with the same CMOS-SOI technology. Accordingly, the GMOS sensor, processed in low cost CMOS-SOI technology, promises to become the widely accepted gas sensing approach for mobile applications, including wearables, smart homes as well as smart phones.

Case Study: Implementing an Industrial IoT solution for a Multihead Weighing Machine (MWM)...521

Dor Ma'ayan and Itai Dabran (Technion, Israel)

In this work we present a practical industrial solution using IoT technologies that optimizes the performance of a multihead weighing machine (MWM), a fast, accurate and reliable scale, used for packing food and non-food products. Our approach for optimizing the performance targeted the calibration of the MWM hoppers. We implemented an algorithm that calculates the optimal weight of the hoppers and modifies it in accordance to an observed factory setting. We demonstrate the effectiveness of the proposed method with a virtual emulation of an MWM in a leading Israeli frozen vegetables producer. Using the simulation, we changed factory settings that decreased the overfill by nearly 300%.

Ad-hoc network recovery after severe disaster...525

Arie Reichman (Ariel University & Ayecka Communication Systems, Israel); Shahaf Wayer (Ariel University, Israel)

In this paper, a method of recovering communication after a disaster is presented. It consists in spreading in the area access points, using drones for examples. The access points allow persons who have personal phones with wireless connection capability, to communicate via these access points. The access points form a wireless mesh network which enable access to gateways that remained after the disaster in the neighborhood of the disaster are or gate ways that can be added after the disaster. The reliability of such a system is analyzed.

A Possibility: Beyond the Channel Capacity in the Low SNR Regime...528

Bingli Jiao, Dongsheng Zheng and Mingxi Yin (Peking University, China); Yuli Yang (University of Chester, United Kingdom (Great Britain))

The paper proposed a method that organizes a parallel transmission of two signals to be separated from each other at receiver through Hamming- to Euclidean space, where the conventional problem of achievable bit rate (ABR) is converted to that of the ABR's summation with respect to the two separated signals. Actually, the mutual information is separated accordingly into two. Since the mutual information is non-linear function of signal power in general, the separation brings a chance for achieving higher ABR. The proposed work proceeds along the above thinking and achieves higher bit-error-rate (BER) performance in comparison with BPSK as shown in the simulations. Moreover, one can find theoretically beyond of channel capacity of BPSK input.

UAV-assited Wireless Powered Sensor Network over Rician Shadowed Fading Channels...532

Stefan Panić (Tomsk Polytechnic University & University of Priština, Serbia); Tharindu Ponnimbaduge Perera and Dushantha Nalin K. Jayakody (National Research Tomsk Polytechnic University, Russia); Caslav Stefanovic (Faculty of Natural Sciences and Mathematics, Kosovska Mitrovica, Serbia); Bojan Prlinčević (Higher Technical Professional School Zvecan, Serbia)

In this paper, we are observing scenario of unmanned aerial vehicle (UAV) data collection from sensor network, where each sensor harvests energy from the data-collecting UAV for its own information transmission. In first time instant, the wireless energy transfer (WET) to sensor nodes is performed, while in second time instant UAV collects data from sensor nodes. In order to take into account the possibility of occurrence of obstacles, that could block the line-of-sight (LOS) link in-between sensor nodes and UAV, and to in order to observe fluctuations of the LOS signal that are brought by shadowing effect, we have used the assumption of Rician Shadowed fading channels and analyzed the outage probability (OP) properties of such network. Closed form expression are derived for OP, and OP features are observed and discussed in the function of system parameters such are shadowing severity, targeted information rate, UAV location, and the time ratio of WET.

Directivity Enhancement of Tight Couplers...N/A

Oz Sorkin, Eldad Holdengreber, Moshe Averbukh, Shmuel E. Schacham and Eliyahu Farber (Ariel University, Israel)

An enhancement of 22 dB in directivity and 15 dB in return loss was achieved in an improved wiggly-line coupler. The improvement was obtained by introducing two new degrees of freedom to the wiggly-line. Heat maps of coupling, directivity, and return loss, as a function of the new degrees of freedom, show previously unavailable fine-tuning capabilities, from which optimal parameters were derived. The use of the improved wiggly-line allows a better even- and odd-mode phase velocity compensation, and an improvement of 42% of even- and odd-mode velocity difference is shown. The improved wiggly-line concept is used to design a tight, tandem, 1.6dB coupler as a center stage of 3-stage symmetrical wideband, 6-18 GHz, 90-degree hybrid coupler implemented in microstrip coupled line topology using bond wires for the tandem section. The loose stage is designed using periodic, quasi-lumped, capacitively-loaded coupled lines. A CST simulation of each design step is shown.

A 1.8mW, 60GHz Mixer First I/Q Receiver in 28nm CMOS...N/A

Duha Gharaba (Technion & Intel, Israel); Emanuel Cohen (Technion Institute of Technology, Israel)

This work presents an ultra-low power and low noise mixer first 60GHz I/Q receiver front end in a 28nm process. I/Q receiver consists of symmetrical I and Q stages, quadrature hybrid for 90 degree shift between I and Q, and has differential outputs at baseband followed by baseband amplifier with differential input and single ended output. Each I and Q stage is composed of differential mixer biased at subthreshold to achieve low DC power consumption of 1.8mW. Receiver architecture is targeted for low LO to RF leakage, and low LO drive. The receiver size is 0.22 × 0.23mm². Simulation results show a minimum single-sideband noise figure (NF) of 5.8 dB with power consumption of 1.8mW from 1.1 V supply, conversion Gain of 29.1dB, RF bandwidth of 6GHz and IF supports 2GHz channel with LO power of -7dbm and low LO to RF leakage lower than -80dB. Simulation results show that this I/Q receiver can be used for ultra-low power and low noise mmW phased array systems for 5G.

Characterization of Diamond Colors via Microwave Spectroscopy...537

Yossi Rabinowitz, Asher Yahalom, Yosef Pinhasi, Haim Cohen and Ariel Etinger (Ariel University, Israel)

The color grading of diamonds is affected mainly by the mode/concentration of nitrogen contamination in the diamond and to much lesser extent by structural defects in the crystal, although in very rare cases boron contamination also causes the appearance of a bluish grayish color. The characterization of rough diamonds for the jewelry industry is usually carried out by spectroscopic instrumentation (in the UV-visible or the Infra-red spectral range) or by XRD/surface techniques. However, the electromagnetic properties of diamonds in longer wave lengths can also shed light on their composition and structure and are much less sensitive to surface effects. The electromagnetic properties of several polished diamonds with different nitrogen concentrations have been determined. Some waveguides in the frequency range of 8-26 GHz and a polyethylene container to contain the diamonds to be studied have been designed and produced. The results have indicated that there is a good correlation between the nitrogen impurity content and the S12 parameter of a transition signal in the waveguide. Thus, it can be concluded that one can use measurements of the electromagnetic properties of diamonds in order to determine their color grading. In addition, a good correlation has been observed with the FTIR measurements of the diamonds.

mmW wireless communication system based on QPSK modulation format using photomixer and coherent detection...542

Asemahegn Asi Wudu (Ariel University, Israel); Daniel Rozban (Ariel University & Ariel University, Israel); Amir Abramovich (Ariel University, Israel)

Millimeter wave (MMW) frequencies (30 - 300 GHz) are promising solution the increasing demand of high data rate, UHD multimedia, HD gaming, security and surveillance. The generation of CW signal at MMW band and above is essential. We experimentally demonstrate MMW wireless communication system at W-band (75 - 110 GHz) with on-off keying (OOK) modulation format using optical heterodyning technique and digital coherent detection. The generation of MMW carrier signal and the wireless photonic transmission system enabled by using commercial off-the-shelf, ultra wideband and antenna integrated InGaAs p-i-n photomixer. The MMW carrier signal received and detected using Schottky barrier diode (SBD) integrated with MMW antenna.

Back To Back Wide-Band CPW-To-Waveguide Transition with RF MEMS Shunt Switch in W-Band...547

Apaar Kapoor (IIT Delhi, India); Shiban K Koul (Indian Institute of Technology Delhi, India); Ananjan Basu and Pranav Shrivastava (Indian Institute of Technology, Delhi, India)

MEMS shunt switch mounted on CPW is proposed to be integrated with CPW-to-rectangular waveguide transitions at both ends in W-band. The MEMS shunt switch is of low actuation voltage with high isolation SPST switch. The transition is probe based without any mechanical contact and is thus easy to fabricate. Measured results for X-band design is in well agreement with the simulations carried out in high frequency structure simulator. W-band results are thus simulated on similar lines and presented. In both cases, the return loss is over 15 dB and an insertion loss of less than 1 dB mostly over the band. The switch states are simulated being integrated with CPW-to-waveguide transitions for ON and OFF states for RF and S-parameters studied in W-band and found satisfactory.

A Comparison Criterion Among Different Planar Nanoantennas for Rectenna Application Design: The Cases for Dipole, Bowtie, Spiral and Log-Periodic...N/A

Nelmo Cyriaco Silva and Luiz Kretly (UNICAMP, Brazil)

This paper presents the establishment of a simple criterion for the nanoantenna design. The motivation for this research is to propose a design guideline to planar nanoantennas that could be applied to rectenna devices. Due to the efficiency limits of solar cells, other solar energy converting technologies are becoming increasingly attractive. One of this promising device is the Rectifier-Antenna or rectenna. It consists of a nanoantenna, it must operate in the Infra-Red spectra of solar radiation, with an embedded rectifier and filter. In this work, four types of nanoantennas are simulated: dipole, bowtie, spiral and log-periodic. Attempting to circumvent the lack of criterion for planar nanoantennas for application in rectenna systems, the criterion here established is to mantain the total dimensions equal for all types of nanoantennas as stated by Wheeler The gain established by Harrington is compared to the simulated ones. The results dictate that it is a reasonable criterion to obtain, at first order, the best nanoantenna candidates.

RRP: Reinforced Routing Policy Architecture for MANET routing...553

Aviel Glam (Rafael Advance Defense Systems Ltd., Israel); Barak Farbman (Rafael & Technion - Israel Institute of Technology, Israel); Ariel Shleifer (Ben Gurion uni, Israel)

In this paper we present a novel architecture for obtaining a routing scheme for mobile ad-hoc networks (MANETs). The goal is obtaining a well-suited routing table for maximization of the message completion ratio (MCR) while keeping low delay. We designed a system architecture that uses an extended routing table and any side information available to the node. Side information can come in the form of physical layer indications (SNR, RSSI, etc.) or congestion (e.g. output queues length) for example. We modeled a highly dynamic MANET environment as a Markov Decision Process (MDP) and deployed reinforcement learning (RL) techniques as training database augmentation, hybrid reward, adaptive learning rate and assisted learning methodology (bounding the learning process and outcome). The resulting routing policy has a probabilistic element regarding transmission to every next-hop option and it out-performs current policies both in different network loads and different noise environments.

Studying an Optimal Approach to Distribute Signals through Fiber-Wireless Fronthaul Network...559

Mikhail Belkin (MIREA - Russian Technological University, Moscow, Russian Federation); Tatiana Bakhvalova and Alexander Sigov (MIREA - Russian Technological University, Russia)

In the paper, we compare in detail the three versions of distributing signals through fifth-generation fronthaul communication network of fiber-wireless architecture with a wireless section operating in MMW-band: in baseband, in intermediate-frequency band, and in radio frequency band. In the result, the advantage and the limits of effective application for intermediate-frequency band transmission are defined and confirmed by a simulation. The study showed that in the case of transmission even in the lower part of the MMW-band (40 GHz), the standard for 64-QAM EVM limit of 8% was achieved when the maximum length of the fiber-optics link was almost 3 times shorter compared to transmission at IF-band (15 GHz) even when using the most promising type of optical modulator.

16:20 ***Advanced Wafer Level Adhesive and Encapsulation Solutions...N/A***

Ruud de Wit (Henkel, The Netherlands)

Advanced Wafer Level Adhesive and Encapsulation Solutions

16:35 ***Enhanced Cooling of Electronic Chips Using Combined Diamond Coating and Microfluidics...N/A***

Gilad Yossifon (Technion, Israel)

We investigate [1] the impact of the combined diamond heat-spreading layer and microfluidic convection on the performance of a model electronic chip heated locally. Experiments are carried out and a finite element method is used to simulate the thermal response of the device under transient step-wise (without flow) and steady-state (with flow) operation conditions up to heat flux values of 38 and 190 W/cm2, respectively. In all cases, the temperature on the heated outer silicon surface did not exceed 100 °C. The temperature field contour has an oval shape for transient heating without flow and a funnel shape for steady-state heating with flow. For a step-wise heat flux of 38 W/cm2, the differences between temperatures at the center of the resistor and at the outer surface edge after a time interval of 8 s are 5, 3, and 1 °C for the chips without a diamond layer, with a 100-μm diamond layer, and only a 400-μm diamond, respectively, which proves the enhanced spreading due to the diamond layer. Under steady-state conditions at a heat flux of 190 W/cm2 and volumetric flow rates of water between 2 and 5 ml/min, the surface temperature decreases by approximately15% for silicon wafer with a 100-μmdiamond layer and by approximately 22% for a 400-μm diamond as compared to heating without the addition of diamond. Of crucial importance is the proximity of the diamond layer to the heat source, which makes this method advantageous over other thermal management procedures, especially for pulsed operating conditions and hot spots.

16:50 ***SAW and BAW Wireless Resonator Temperature Sensors for Surgery...N/A***

Sergey Bogoslovsky (JSC RADAR MMS, Russia); Gennady Sapozhnikov (JSC Radar mms, Russia); Ivan Antsev (JSK Radar mms, Russia); Sergei Zhgoon and Alexander Shvetsov (National Research University MPEI, Russia)

The paper provides a comparison of passive implantable sensors that can be used in medicine. The focus is on temperature sensors, which are in demand in traumatology and medicine. Two types of sensors are considered. The first type of sensor is made according to the technology of surface acoustic waves, and the second type of sensor is made according to the technology of bulk acoustic waves. The sensors developed were implanted and examined in sheep. The best results were shown by the sensor based on the technology of bulk acoustic waves. The limit of the implantation depth into biological tissue is 20 cm.

Wednesday, November 6

Wednesday, November 6 9:00 - 10:50

AP6: Propagation and Modeling

Room 3

Chairs: Dmitry Chizhik (Nokia Bell Labs, USA), Eran Greenberg (RAFAEL, Israel)

9:00 ***Directional Gain Measurements at 28 GHz for 90% Indoor Coverage...N/A***

Dmitry Chizhik (Nokia Bell Labs, USA)

Adequate coverage with high gain antennas is key to realizing the full promise of the wide bandwidth available at mm/cm bands. We report extensive indoor measurements at 28 GHz, with over 600 links (8 offices, over 7 million individual power measurements) with/ without line-of-sight (LOS) using a specialized narrowband (CW) channel sounder, capable of reliable measurements up to 171 dB path loss to characterize coverage within 90% confidence interval. To quantify antenna gain degradation due to scattering, azimuthal power spectra were measured using a 10 deg spinning horn capturing a full azimuth scan as fast as every 200 ms. Gain degradation was within 4 dB in the corridor and 7 dB inside rooms with 90% probability.

9:20 ***Over-the-City UAVs Swarm Communications Channel Model...563***

Eran Greenberg (RAFAEL, Israel); Edmund Klodzh (Rafael, Israel)

The use of UAVs swarm based on drones for various applications is a rapidly growing research field for the smart city. Knowledge of the wireless propagation channel is crucial for designing an efficient communication system and for evaluating its performance. This contribution is focused on LOS/NLOS links between UAVs in the swarm for flight altitudes close to building rooftops. On the one hand LOS conditions are not always dominant or even present in this scenario, and on the other hand there is no complete building blockage. Hence, it is necessary to consider the presence of multipath phenomena reflection and diffraction from building rooftops. This paper describes ray tracing simulations which were performed in order to estimate the contribution of multipath components and to develop a channel model for UAVs swarm communications links.

9:40 ***Propagation and Time-of-Arrival of VLF Pulses in the Earth-Ionosphere Waveguide...568***

Sherman Marcus (Technion - Israel Institute of Technology, Israel); Eran Greenberg (RAFAEL, Israel); Ariel Epstein (Technion - Israel Institute of Technology, Israel)

Very low frequency (VLF) propagation in the earth-ionosphere waveguide has been of interest for many decades. Most computational capabilities have been performed for a single frequency, with time-dependent results (such as those applied to lightning) obtained by inverse-Fourier-transforming the entire fields over a spectrum of frequencies. But if time-of-arrival (TOA) of a wave pulse is of interest, a less computationally-intensive method can be employed. Since the field in the waveguide may be represented as a sum of modal fields, and since the group velocity is different for each mode, only the mode with the largest group velocity - the lowest order mode - need be calculated to obtain TOA information. This principle is demonstrated in detail for a simple waveguide, and applied to the earth-ionosphere waveguide.

10:00 ***Modelling Large-Scale Signal Fading in Urban Environment Based on Fuzzy Inference System...573***

Segun I Popoola (Manchester Metropolitan University & Covenant University, United Kingdom (Great Britain)); Aderemi A. Atayero (Covenant University, Nigeria); Bamidele Adebisi (Manchester Metropolitan University, United Kingdom (Great Britain)); Abigail O Jefia (Covenant University, Nigeria); Kingsley Ogbeide (Landmark University, Nigeria); Andrew Gibson (Manchester Metropolitan University, United Kingdom (Great Britain))

Path loss models are veritable tools for estimation of expected large-scale signal fading in a specific propagation environment during wireless network design and optimization. In this paper, the capability of Adaptive Neuro-Fuzzy Inference System (ANFIS) to establish non-linear relationship between related variables was explored for path loss predictions at Very High Frequency (VHF) band in a typical urban propagation environment. Drive test measurements were conducted along various routes in the urban area to obtain terrain profile data and path losses of radio signals transmitted at 92.3 MHz and 189.25 MHz frequencies. Adaptive Neuro-Fuzzy Inference System (ANFIS) was modelled to predict the magnitude of large-scale signal fading (i.e. path loss) based on the longitude, latitude,distance and elevation of the receiver's location. Fuzzy Inference System (FIS) was generated based on Fuzzy C-Means (FCM) and subtractive clustering methods. Model performance evaluation results showed that the ANFIS model developed based on FCM clustering method yielded the least prediction errors with a Root Mean Squared Error (RMSE) value of 0.88 dB. Whereas, the International Telecommunications Union Radiocommunication (ITU-R) had earlier set a maximum allowable RMSE value of 6 dB for urban propagation environments. Thus, ANFIS technique produced a very efficient large-scale signal fading prediction model for VHF network design and optimization in urban areas.

MM2: Metamaterials 2

Room 4

Chairs: Constantine A. Balanis (Arizona State University, USA), Ozgur Ergul (Middle East Technical University, Turkey)

9:00 ***Circular Metasurfaces for Curvilinear Radiating Elements...578***

Constantine A. Balanis (Arizona State University, USA)

The integration of radiating elements with metasurfaces have enhanced the radiation performance of antennas. In this paper, circular metasurfaces are reviewed and analyzed. The placement of curvilinear radiating element in the vicinity of a circular metasurface is investigated and compared to rectangular geometries. A superior performance is observed when circular metasurface ground planes are utilized with curvilinear radiating elements.

9:30 ***Analysis of Composite Structures Involving Near-Zero-Index Materials...580***

Yesim Koyaz, Hande Ibili, Bariscan Karaosmanoglu and Ozgur Ergul (Middle East Technical University, Turkey)

We consider numerical solutions of electromagnetic problems involving near-zero-index materials with permittivity and/or permeability values close to zero. These types of problems are inherently multiscale due to the large variety of the wavelength from very large values to ordinary values in the same problem. In addition to developing a stable formulation for extreme values of the intrinsic impedance, we employ a broadband multilevel fast multipole algorithm based on approximate diagonalization for efficient solutions. Examples involving near-zero-index materials inside ordinary waveguides are presented to demonstrate interesting electromagnetic responses of these exotic materials, as well as the effectiveness of the developed solver.

9:50 ***Metasurfaces for Radar Cross-Section Reduction...582***

Constantine A. Balanis and Anuj Y. Modi (Arizona State University, USA)

This work reviews the most recent advancements in the techniques utilized for the reduction of Radar Cross Section (RCS) incorporating metasurfaces. Fundamental theory is briefly reviewed then followed by well-known broadband RCS-reduction metasurface designs.

10:10 ***Numerical Modeling of Tunable Multilayer Graphene-Based Metasurfaces and Metadevices for Nanophotonics...N/A***

Alexander M. Lerer (Southern Federal University, Russia)

Numerical approaches for modeling of nanophotonic metadevices based on multilayer graphene metamaterials and metasurfaces by using rigorous mathematical models to solve the 3D diffraction boundary problems are developed. The models are based on the solution of Maxwell`s equations with electrodynamic boundary conditions simultaneously with a model of the graphene surface conductivity determined from the Kubo formula. Using two methods, such as the approximate boundary conditions and volume integrodifferential equation approaches, the results of numerical simulation of tunable THz broadband absorbers and THz reflection polarizers based on multilayer metasurfaces of graphene nanoribbon elements at the resonant THz frequencies were obtained. Using the deterministic electrodynamic model based on the decomposition approach by autonomous blocks with Floquet channels and the probabilistic model, the scattering parameters of THz filter based on the periodic multilayer graphene-dielectric metamaterial, depending on the value of chemical potential (the external bias electric field) were calculated at THz frequency range

10:30 ***4D Scatterers based on Optically Reconfigurable Volumetric RF Metamaterials...N/A***

Dmitry Filonov (Tel Aviv University, Israel); Dmitry A Dobrykh and Anna Mikhailovskaya (ITMO University, Russia); Pavel Ginzburg (Tel Aviv

University, Israel)

Artificially created media (metamaterials) introduce additional valuable degrees of freedom into electromagnetic design, making both geometrical shapes and material susceptibilities to be accessible. Dynamically reconfigurable metamaterials can significantly enlarge those capabilities by employing the fourth time dimension as an additional controllable parameter. Here we design and experimentally demonstrate the first of a kind reconfigurable volumetric metamaterial-based scatterer, which electromagnetic properties are controlled dynamically with light. In particular, resonances of split ring resonators, assembled within an array, hybridize and give rise to a collective mode, which poses properties of artificial high-frequency magnetism. Resonant behavior of each individual ring is controlled with a photodiode, which allows obtaining fast switching between positive and negative values of macroscopic effective permeability. As the result, artificial RF magnon resonant excitation within a subwavelength spherical scatterer is governed by light intensity. Four-dimensional control (both space and time) over electromagnetic scattering open new venues for modern applications, including wireless communications and automotive radars to name just few.

PT2: Packaging & Thermal Management 2

Room 5

Chairs: Avram Bar-Cohen (University of Maryland, USA), Aviv Ronen (Rafael, USA)

9:00 ***Pushing the Borders of Fan Out Wafer Level Packaging...N/A***

Horst Theuss (Infineon Technologies AG, Germany)

Fan Out Wafer Level Packaging (FOWLP) has originally been developed for high pin count applications and - due to its superior RF properties - has quickly conquered high frequency applications, e. g. in the field of 77 GHz Automotive Radar transceivers. The talk will review current limits of FOWLP and then present recent developments on how these challenges can possibly be addressed. A specific topic will be the adaption of the process flow to MEMS and sensors. Details of a respective process option will be presented for the case study of a MEMS microphone. A second section will touch approaches on further improvements of the RF capability of FOWLP systems - e. g. by specific routing concepts or integration of antennas into the package. Eventually, these developments will contribute to extend the heterogeneous integration capability of the FOWLP platform. They also demonstrate the ongoing dissolution of the old-fashioned firm border in between Frontend (wafer fabs) and Backend (chip assembly).

9:30 ***CT Detectors - Design Challenges...N/A***

Raffy Goshen (Philips Healthcare, Israel)

CT Scanner

9:50 ***Flip Chip Ball Grid Array (FCBGA) Package Development for a High Bandwidth Switch...N/A***

Nuphar Lipkin (Mellanox, Israel)

The massive amounts of data created by application such as Artificial Intelligence (AI), Autonomous cars and the Internet of Things (IOT) require fast transfer and processing of exponentially growing amounts of information within data- centers. Higher bandwidths at faster data rates are a must. As a consequence, an increase in die and package size are required. Dimension and power growth step up the challenges for package performance, reliability and cost. In addition, moving to advanced Si manufacturing technology nodes (7nm, 5nm) reduces significantly yield due to the increase in process complexity. A 70X70mm FCBGA Multi-Chip Module (MCM) test vehicle was developed by Mellanox using daisy chain Si dice. Process & material optimization had been performed as well as reliability validation of this complex MCM package. The presentation will focus on the challenges Mellanox & OSAT faced during the MCM assembly process, including: Material selection Lid Coplanarity CTE mismatch Reliability validation

10:10 ***Packaging for Electro-Optical Devices...N/A***

Galit Zilberman (Elbit Systems, Israel)

Electro-optical device are sensitive to many parameters as temperature, contaminations and humidity. Using hermetic packaging techniques the reliability of the device increases and the need for schedule maintenance almost eliminate. The package serves as faraday cage that reduce EMI effects. Heat spreader is an integral part of the package that stabilized the device temperature. Eventually a getter is an integral part of the lid that control the humidity level and contamination. In this presentation we will present design considerations for electro-optical packaging. Some examples of brazing techniques of optical elements will be presented.

10:30 ***Design for Reliability for Microelectronic Packages Manufactured in Low Volumes...N/A***

Jonathan Rothschild (Rafael, Israel)

The cost of failure correction or reparation in products increases as a function of life cycle stage, e.g. correcting failures after the qualification stage is much more expensive than correcting the same failures during the design stage. Another point is that the high volume microelectronics industry uses rigid standards either developed internally or based on international standards, JEDEC being the most prominent committee. These standards are generally qualification-based and their results are either pass or fail. For low volume manufacturing it is not economically to perform such extensive qualification tests due to a lack of samples and/or lack of budget. In order to improve the reliability of the design itself it is possible to use a wide range of tools and methods. Some of them are in congruence with tools used in quality assurance, such as FMEA (Failure Mode and Effect Analysis) and DOE (Design of Experiment) and some are specific to assuring the long term reliability, such as accelerated life tests, physics of failure and life data analysis. This type of qualification is also described by military standards (i.e. Mil-HDBK-338) and commercial standards (e.g. JEDEC-JEP94). It is possible to combine these tools into one unified methodology for ensuring the reliability of microelectronic packages manufactured in low volumes. This methodology is valid in either incorporating customer reliability requests or works independently, in the case of absence of customer reliability requests.

UA1: Short Course: Unconventional Array Design 1

Room: Royal H

9:00 ***Short Course: Unconventional Array Design for New Generation Communications and Sensing...N/A***

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

The objective of the short course is therefore to provide the attendees the fundamentals of Antenna Array synthesis, starting from intuitive explanations to rigorous mathematical and methodological insights about their behavior and design. Moreover, recent synthesis methodologies will be also discussed with particular emphasis on unconventional architectures for complex communications and radar systems within a new optimality framework. More specifically, advanced methodologies and architectures will be introduced, and their application in the synthesis of linear arrays will be illustrated also with a set of "hands on" software examples.

DC6: Passive Devices and Techniques

Room: Royal I

Chair: Andrea Bevilacqua (University of Padova, Italy)

9:00 ***Moving Beyond S-Parameter Files: Advanced Scalable and 3D EM Models for Passive Devices...586***

Larry Dunleavy (Modelithics, USA)

- S-parameter data files remain the most commonly available "model" for representing passive devices in the microwave industry. Physically-motivated equivalent circuit models can be setup to scale accurately with part-value, substrate properties and other parameters, such as solder pad dimensions. Still such circuit models cannot generally for account for electromagnetic coupling interactions between microwave components and between components and consequently full-wave Electromagnetic (EM) analysis has become a crucial step for radio frequency (RF) to account for interactions between components and between components and their surrounding shielding and interconnect environment. New technology, recently available in some EM simulators, allows for encrypting geometry and material details to protect vendor manufacturing IP and enable 3D EM models to be shared with a wider design community helping designers reduce design risk and re-work and improve time-to-market for today's increasingly compact and complex product form factors.

9:30 ***Recent Advances in mm-wave Characterization, Calibration and de-embedding techniques...N/A***

Andrej Rumiantsev (MPI Corporation, Germany)

Wafer-level S-parameter measurement at mm-wave and sub-mm wave frequencies plays a crucial role in the model development and IC design verification of advanced semiconductor technologies. Accurate calibration of the entire wafer-level measurement system to the RF probe tip end or to the intrinsic device terminals is a critical success factor for extracting trustable device model parameters and characterizing true performance of a RF IC. Challenges of obtaining accurate, reproducible and trustable results drastically increase with the frequency: methods and practices that have been working well, tend to fail or to yield results which are difficult to interpret. This work discusses specifics of S-parameter measurement and calibration techniques at the wafer-level. Special attention is paid to the similarities and differences between RF calibration and parasitic de-embedding methods and to get the best out of these two. This work also includes practical examples of how to minimize the impact of calibration residual errors on the accuracy of measurement results.

10:00 ***Integration of Filters into Phased Array Antenna Panels...N/A***

Hjalti Sigmarsson (University of Oklahoma, USA)

With the ever-increasing bandwidth requirements of current and future wireless services, the radio-frequency spectral environment will continue to grow more crowded. In anticipation of this development, multifunctional radar systems that can perform multiple missions, such as air-traffic control and weather monitoring, have grown in popularity in recent years. Microwave filters are needed to protect the systems from nearby interference. In this presentation, methods for integrating microwave filters directly into the antenna array panels are presented. A comparison between using different filter implementations, such as miniaturized distributed elements, lumped elements, and quasi-lumped elements, is reported. The goal is to integrate low-loss filters without adding any volume to the array. Overall, these filters can be used to mitigate interference with minimal impact of systems sensitivity, and thus ensuring proper radar operation in the crowded electrical environments of the future.

10:30 ***Three Planar Devices for Extracting Capacitance per Unit Length...593***

Nina B. Popovic (University of Colorado at Boulder & National Institute of Standards and Technology, USA); Eric Marksz (University of Maryland, USA); Aaron Hagerstrom, James Booth, Edward Garboczi, Nathan Orloff and Christian Long (National Institute of Standards and Technology, USA)

Circuit designers need materials with well-known properties to make predictive circuit models, which is particularly challenging in the millimeter-wave regime. Typical material characterization approaches include on-wafer devices. To get the material properties from these measurements, on-wafer calibrations require a known characteristic impedance. Often, this requirement uses low-loss substrates and a series or shunt load to calculate the capacitance per unit length of the transmission line. This paper investigates three devices with independent analysis procedures to estimate the capacitance per unit length. Although the devices have the same cross section, we observed a significant different in the extracted values and discuss possible mechanisms which may contribute to this difference.

CS5: New Communication Techniques and Applications

Room: Royal J

Chair: Jay A Weitzen (University of Massachusetts Lowell & Airvana, USA)

9:00 ***Case study: Implementing a Personal Area Network MAC Protocol for Inaudible Sound Waves...598***

Itai Dabran (Technion, Israel); Alon Eilam (Technion - Israel Institute of Technology, Israel); Guy Menhel and Yuval Ron (Technion, Israel); Guy Shofen (Sonarax, Israel)

Popular wireless personal area network technologies are usually based on short radio waves. Notable examples are Bluetooth, ZigBee and Wi-Fi. In this paper, we describe a MAC protocol for wireless networks, mainly for Android smartphone devices, based entirely on high frequency sound waves. Beyond the human hearing range, ultrasonic waves are a good and cheap complementary solution for environments where other forms of communications are disabled or interrupted. Our main contribution is a packet-based MAC protocol for wireless ultrasonic networks that supports generic and low-bandwidth applications such as smart home, remote control, and entertainment devices.

9:20 ***Improving the accuracy and quality of wireless coverage measurements using Autonomous Drones and Wheeled Robots...603***

Jay A Weitzen (University of Massachusetts Lowell & Airvana, USA); Joshua Watts, Rachel Wakim, Emi Aoki, Sivly Lay and Naye Yoni (University of Massachusetts Lowell, USA)

Wireless measurements are critical to the deployment of advanced wireless systems such as WiFi, 4G LTE, and 5G. Detailed measurement data are required to map the level and quality of coverage for service level agreements (SLA), to characterize interference prior to and after deployment, and to characterize and optimize handoff regions. These often-repetitive measurements are time consuming, labor intensive, and prone to human error, especially when performed repetitively. Many former graduate students have memories of hauling a wagon or a large backpack plus laptop around while making wireless measurements. This paper discusses the work we are doing to improve the wireless measurement process through automation. In particular, for small to medium indoor venues we are experimenting with wheeled robotic platforms and for large outdoor venues such as stadiums or those with lots of stairs, we are experimenting with using UAV's (drones) for mapping wireless coverage. Robot and UAV based platforms provide superior localization and higher resolution and quality data than conventional manual methods

9:40 ***Location-Domain Channel Representation for Estimating Distributed MIMO Channels...608***

Arkady Molev-Shteiman and Xiao-Feng Qi (Futurewei Technologies, Inc., USA); Laurence Mailaender (Huawei Technologies & Alcatel-Lucent, USA)

We propose a location-domain channel representation, and apply it to channel estimation for distributed MIMO (D-MIMO) networks. The approach contrasts with various angle-domain formulations which appear well-suited for a collocated large array where the far-field assumption allows an angle-domain channel representation, but are ill-suited to geographically distributed arrays (large and small), as in, e.g. densely deployed 5G cellular networks. Our alternative location-domain representation avoids such difficulties, by indexing the multipath channel by the locations, instead of angles, of user terminals or access points. Furthermore, it naturally incorporates 3D surrounding information in the form of a 'channel database,' achieving scene-specific SNR gain and ease of machine learning. We demonstrate the efficacy of our proposal through simulation of simple channel estimation algorithms over a narrowband channel.

10:00 ***An Efficient Traffic Control Management in the Smart City...614***

Itai Dabran and Ben Hunter (Technion, Israel)

In this work we present a practical solution for traffic congestion problems using simple IoT technologies that configure traffic light interconnection. To date, many proposed solutions have required either a hardware manipulation of private cars or installation of complex software systems in a huge number of traffic lights. In our smart city traffic simulation, we show that optimizing traffic lights alone - without any modifications to the vehicles - can improve the traffic congestion rate and severity by more than 20%. Our proposed scheme is also easy

to implement as opposed to current approaches that present enormous challenges to today's cities both in terms of budget requirements and operational scale, and heavy bandwidth demands from the vehicular cloud.

10:20 ***Handling traffic loads in a smart junction by social priorities...620***

Nadav Voloch (Ben Gurion University of the Negev, Israel); Orly Barzilai, Orna Lavi Steiner, Zohar Fine, Eran Brayer and Idan Proshtisky (The College of Academic Studies, Or Yehuda, Israel)

Smart junctions are the subject of many researches in the past few years. This research deals with the case of a smart intersection, handling traffic loads while taking into consideration different aspects of social prioritization. While learning the problem of traffic and its flow in an optimal way to save time and fuel for all travelers on the way, giving preference to urgent cases (dilemmas) and different types of vehicles (size and number of passengers), creates a more morally accurate picture of the traffic as a human interface. An example of such priority at the junction could be a woman in labor in a private vehicle, that is not formally prioritized since it is not an emergency vehicle. Traffic lights around the world are based on orderly programming of passage between the different traffic directions. The technology that measures the amount of traffic can change the duration of green light that is activated or even skip an instance of passage in case of sensor detection of an empty lane. Our research and system, presented in this paper, unlike all other systems, is not based on a specific order of traffic flow at the junction, but reopens each sample and analyzes the junction by its passenger data, prioritizing the social aspect of the vehicle's travelers. The system performs each sampling in a certain time period by the physical aspect of the vehicle and uses a prioritization system, which performs a parametric calculation of these social aspects. The system checks all the possibilities of allowing green light for larger traffic and considers the criteria for prioritizing a traffic load. The algorithm that was developed for this system can calculate each green time according to real-time data of the junction's vehicles and chooses the optimal traffic route, accordingly.

Wednesday, November 6 11:10 - 13:00

AP7: Antenna Design & Manufacturing

Room 3

Chairs: Pavel Ginzburg (Tel Aviv University, Israel), Meisong Tong (Tongji University, China)

11:10 ***Design of Advanced Reflectarrays for Future Satellite Applications...N/A***

Andreas Ericsson, Min Zhou, Stig Sørensen, Niels Vesterdal, Michael F. Palvig, Oscar Borries, Jakob Rosenkrantz de Lasson, Tonny Rubæk, Peter Meincke and Erik Jørgensen (TICRA, Denmark)

In recent years, there has been significant interest in reflectarray antennas and the latest research have shown that reflectarrays can be used to provide solutions which are otherwise not possible using existing solutions. In this paper, we present a general design framework for the design of advanced reflectarrays and show how it can be used to design reflectarrays for future antenna system applications.

11:30 ***Selective Metallization of Graphene-based Polymers for Volumetric 3D-printed Antennas...625***

Pavel Ginzburg and Dmitry Filonov (Tel Aviv University, Israel)

Employment of modern 3D-printing technologies allow efficient exploration of the third space dimension, providing advantages over conventional planar architectures. In particular, volumetric electromagnetic antennas can outperform their planar counterparts. Here a new approach to fabrication of electromagnetic devices is developed and applied to antennas, implemented on b-spline surfaces. The antenna skeleton and the support were simultaneously printed with different polymer materials - PLA mixed with graphene flakes and pure PLA, respectively. Weakly dc-conductive graphene PLA-based skeleton was post-processed and high quality conductive layer was selectively electrochemically deposited on it. The antenna devices were found to demonstrate radiation performance, similar to that achievable with conventional fabrication approaches. However, additive manufacturing of RF antennas provides superior capabilities of constructing tailor-made devices with properties, pre-defined by non-standardized end users.

11:50 ***An Optimized Design for Compact Patch Antenna Using Artificial Electromagnetic Structure...630***

Meisong Tong, Meng Meng Li, Guochun Wan and Li Zhang (Tongji University, China)

A compact microstrip rectangular patch antenna with defeated ground structures (DGSs) is proposed. The DGS with a better performance is chosen so that the reduction in the size of antenna can be achieved. In order to eliminate the negative impact of DGS, a small portion of this patch is truncated so as to acquire a better gain and return loss. This paper elaborate on the mechanism of miniaturization in mathematics and physics respectively and the mathematical model of a single C-shaped ring is obtained. By optimizing these parameters, the size of the antenna can be reduced to 55.58% of the original size while the return loss of the antenna can reach to 37.10 dB. The measurement results indicate that the performance of the antenna can match well with the simulation results.

12:10 ***A Novel Sensor Based on Microstrip Patch Antenna for Detecting Different Gases in Circular Pipe...635***

Meisong Tong, Yun Jie Mao, Qing Xu and Xu Shi (Tongji University, China)

Many industries need a robust sensor to detect and collect information. This paper proposes a sensor based on microstrip patch antennas which are fed by circular waveguide. It can not only realize the function of the antenna but also detect the information about gas as a sensor. When different gases passe through the circular pipe, due to the change of dielectric permittivity, the impedance characteristics of antenna change, which can cause the changes in resonant frequency, return loss, etc. Besides this sensor has advantages of real-time automatic detection, which can reduce the cost of time and manpower. When the inside of the pipe is vacuum, the reflection coefficient of the antenna is less than -20 dB at 24.4 GHz.

12:30 ***An Improved Broadband Circularly Polarized Cross-Dipole Antenna With An AMC Reflector...640***

Wei HE, Yejun He, Long Zhang and Sai-Wai Wong (Shenzhen University, China)

In this paper,we present an improved design method to significantly reduce the volume of circularly polarized (CP) cross-dipole antenna. Unlike the commonly used approaches, the distance between the antenna and the reflector is largely narrowed in this work, which is only 0.13λ0. The proposed cross dipole antenna achieves low profile and broadband characteristics by using stepped rectangular patch arms, parasitic strips and AMC. And CP radiation can be generated effectively for the proposed antenna by connecting the arms of each dipole through a vacant-quarter rings. The overall size of the proposed antenna is 0.88λ0 × 0.88λ0 × 0.13λ0. Simulation results show that a broadband impedance bandwidth (for S11 < -10 dB) of 47.3% (1.81 to 2.93 GHz), a wide 3-dB AR bandwidth of 25.3% (2.16 to 2.78 GHz), the peak gain of 7.8 dBic and the average CP gain of whole operating frequency band of 7.5 dBic are obtained.

MM3: Metamaterials 3

Room 4

Chairs: Kumar Vijay Mishra (The University of Iowa, USA), Giacomo Oliveri (University of Trento, USA)

11:10 ***Metamaterial-by-Design - A Paradigm for the Industrial Synthesis of EM Manipulation Devices...643***

Giacomo Oliveri (University of Trento & ELEDIA Research Center, Italy); Angelo Gelmini and Giorgio Gottardi (ELEDIA Research Center, University of Trento, Italy); Marco Salucci (ELEDIA Research Center, Italy)

An overview of the metamaterial-by-design (MbD) paradigm as applied to the industrial synthesis of electromagnetic (EM) manipulation devices is provided. Thanks to the MbD, the constituent materials of innovative EM devices are regarded as additional degrees-of-freedom (DoFs) allowing to match several conflicting user-defined performance and/or geometric constraints. Innovative applications of the MbD to the multi-scale design of wide angle impedance matching (WAIM) layers and metamaterial lenses are presented, together with an illustrative example concerned with the conformal transformation of linear phased arrays through a novel Schwarz-Christoffel transformation optics (SCTO) MbD technique.

11:30 ***Microwave Response of a Microstrip Circuit Embedding Carbon Nanotube Films...646***

Antonio Maffucci (University of Cassino and Southern Lazio & National Institute of Nuclear Physics, INFN-LNF, Italy); Marco Donald Migliore (University of Cassino, Italy); Fulvio Schettino (Università degli Studi di Cassino, Italy); Daniele Pinchera (University of Cassino, Italy); Alesia Paddubbskaya (Belarusian State University, Belarus); Sarah Sibilia (University of Cassino and Southern Lazio, Italy)

This paper investigates the microwave range response of microstrip circuit where a film of carbon nanotubes is embedded into a microstrip-like circuit. Such a nanomaterial, as well as graphene, is currently embedded into planar structures like patch antennas, to exploit its novel features as, for instance, easy tunability. In view of these applications, in this paper it is analyzed the dependence of the scattering parameters from the geometrical and physical parameters of the circuit. The analysis is carried out either by means of experimental characterization via microstrip technique, and of numerical simulations with a full-wave electromagnetic simulation tool. In addition, by using these two results and by using structural characterization of the nanomaterial equivalent, an equivalent complex permittivity is retrieved, describing the embedded film.

11:50 ***Retrieval of Polarizability Matrix for Metamaterials...650***

Quang Nguyen (United States CCDC Army Research Laboratory, USA); Kumar Vijay Mishra (The University of Iowa, USA); Amir I Zaghloul (US Army Research Laboratory & Virginia Tech, USA)

Exact retrieval of polarizability matrix is of critical importance in designing metamaterials and frequency-selective surfaces. We evaluate practical methods for effectively extracting the polarizability matrix of dielectric and metallic metamaterials. We focus on three approaches: analytical solutions, induced or displacement current distributions, and reflection/transmission parameters. The analytical solutions are limited to particles of canonical shapes; even minor alterations in the structure results in a different analytical model. In case of arbitrary shapes, it is useful to adopt the approach based on the calculation of the induced or displacement current distributions of the excited particle in response to plane wave illumination. A more rigorous estimate of the polarizability matrix for irregular shapes is possible via measured or simulated reflection/transmission parameters. We provide new insights related to the empirical and theoretical analysis of these algorithms. In particular, we show that, wherever applicable, these methods retrieve all components of polarizability matrix identically.

12:10 ***Simple way of Frequency Tuning using Pin Diode of Transmission type Digital Metasurface...655***

Amit Baghel and Shashank Kulkarni (IIT Guwahati, India); Sisir Kumar Nayak (Indian Institute of Technology Guwahati, India)

This article shows the frequency tuning using PIN diode of transmission type digital metasurface. Here, the S21 amplitude of the unit cell in ON and OFF condition of PIN diode is given the digital code of "0" when the S21 value is less than - 8 dB, and "1" when the amplitude is 0 dB. It is observed that when the diode is ON, the 10 x 18 array shows the nature of OFF condition at 4 GHz. Similarly, when the diode is OFF, the array shows the ON nature at 4 GHz, thus getting ON or OFF condition at 2.54, 4, 6.84 GHz depending on the condition of diode. This increases the bandwidth of operation

PT3: Packaging & Thermal Management 3

Room 5

Chairs: Nuphar Lipkin (Mellanox, Israel), Galit Zilberman (Elbit Systems, Germany)

11:10 ***Role of Electronic Packaging in 5G...N/A***

Ivan Ndip (Fraunhofer IZM, Germany)

5G will transform our lives, economy and society. The development of 5G millimeter-wave (mmWave) systems is a challenging task which requires efficient hardware implementation of massive MIMO and hybrid beamforming architectures at mmWave frequencies. For this implementation, advanced electronic packaging platforms and technologies which enable cost-effective, low-loss, reliable and compact integration of high gain mmWave antenna arrays, passive components, RF front-end ICs with beamforming functionalities and baseband ICs are required. In this talk, the role of electronic packaging platforms and technologies on the performance, cost, reliability and miniaturization of emerging 5G mmWave systems will be extensively discussed.

11:40 ***High Precision Dry and Fluxless Die Eutectic Bonding Process...N/A***

Lior Miller (Rafael, Israel)

High precision dry and fluxless die eutectic bonding process

12:00 ***Understanding Variation in High Performance MEMS Resonators...N/A***

Dean Spicer (Teledyne Micralyne, Canada)

Dean Spicer will present WLP and MEMS devices.

12:20 ***High Conductivity Die Attach and Shielding Solutions for RF Devices...N/A***

Ruud de Wit (Henkel, Belgium)

High Conductivity Die Attach and Shielding Solutions for RF Devices

12:40 ***Thermal Simulations of Pulsed GaN HEMT Devices...N/A***

Raoul Guggenheim and Lior Rodes (Rafael, Israel)

GaN HEMTs have replaced GaAs technology in the past years in high-power, high-frequency applications, since the technology has a lot of desirable properties such as high thermal conductivity (SiC), higher breakdown voltage and lower parasitic capacitances. The thermal management of GaN MMIC power amplifier is one of the main show-stoppers when engineering GaN products. The theoretical electrical limit of GaN HEMTs cannot be reached, due to the fact that the high power density during operation lets the chip heat up to not tolerable temperatures at which both the performance as well as the device life-time (MTTF) is reduced. A common method for the thermal characterization of these HEMTs is IR thermography, which reaches lateral resolution of a few microns but can only resolve the top surface's temperature. Additional final elements analysis (FEA) is done in order to calculate the correct junction temperature. In pulsed applications, this extraction process is more difficult, since both the measurements show lower resolutions and transient simulations remain computationally demanding. Multiple methods for calculating peak temperatures in high power switching semiconductor devices have been presented, including model-order-reduction, FEA of the pulse train and the calculation using the thermal frequency domain. In this work, the applicability of a simple analytic formula, used for linear systems is shown and the results are correlated to FEA and measurement data. The data shows good agreement and can be used for reliability calculations.

UA2: Short Course: Unconventional Array Design 2

Room: Royal H

DC7: LO Signal Generation and Distribution

Room: Royal I

Chair: Vadim Issakov (Infineon Technologies AG, Germany)

11:10 ***Low-Phase Noise Bipolar VCOs for Integrated 5G Front-ends...N/A***

Andrea Bevilacqua (University of Padova, Italy)

The talk will deal with the design of low-phase noise voltage-controlled harmonic oscillators (VCOs) implemented in bipolar technologies. The design challenges related to achieving minimum phase noise for a given set of technology parameters (supply voltage, metal stack, varactor devices, etc.) will be discussed with particular emphasis to attaining low phase noise while using varactor diodes, to the use of magnetic transformers in the resonator, and to the selection of the most appropriate oscillator topology. Effective techniques to tackle such issues will be illustrated. Design examples of VCOs operating in the K-band and suitable for 5G applications will be presented.

11:40 ***Challenges in the analysis of innovative oscillator-based circuits for radar, RFID and reconfigurable systems...N/A***

Almudena Suarez (University of Cantabria, Spain)

Challenges in the analysis of innovative oscillator-based circuits for radar, RFID and reconfigurable systems

12:10 ***Transformer-Coupled Octa-Core 60 GHz Push-Push VCO in a 45-nm RF-SOI CMOS Technology...658***

Johannes Rimmelspacher (Infineon Technologies AG, Germany); Robert Weigel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Vadim Issakov (Infineon Technologies AG, Germany)

This work presents a 60 GHz octa-core push-push VCO in a 45 nm partially depleted (PD) Silicon-on-Insulator (SOI) CMOS technology. We investigate the feasibility of coupling eight VCO cores via resonant-tank transformers and discuss circuit topology considerations. The measured phase noise (PN) at 63.4 GHz is −95.3 dB/Hz at 1 MHz offset from carrier. The continuous frequency-tuning range (FTR) is 19 %. The eight VCO cores consume in total 80 mW DC power. The complete circuit, including buffers at the fundamental and second harmonic (H2) outputs, draws 158 mA from a single 1 V supply. The total area of the octa-core VCO excluding pads is 0.18 mm2.

12:30 ***Considerations on 120GHz LO Signal Generation and Distribution for Highly-Integrated Multi-Channel Radar Transceivers...662***

Andrea Bilato (University of Padova & Infineon Technologies AG, Italy); Andrea Bevilacqua (University of Padova, Italy); Vadim Issakov (Infineon Technologies AG, Germany)

This paper presents considerations on the choices related to the design of the generation and distribution network of the LO signal for multi-channel radar transceivers working at 120 GHz. Many constraints regarding output power, bandwidth phase noise and power consumption need to be considered concurrently. Deciding which one is the best solution is not a straightforward choice. This paper shows a systematic comparison of different LO generation and distribution architectures and introduces a figure of merit for the evaluation of the results. Simulations are performed in 0.13um SiGe BiCMOS technology with a 1.8V supply.

CS6: Interference Mitigation and New Approaches in Communications System

Room: Royal J

Chair: Raymond Shen (Keysight Technologies, USA)

11:10 ***A Study of Interference Distributions in Millimeter Wave Cellular Networks...666***

Alireza Alizadeh and Mai Vu (Tufts University, USA); Theodore Rappaport (New York University & NYU WIRELESS, USA)

We study the distribution of the interference power at a typical receiver in a millimeter-wave enabled cellular network. Such interference is random and is highly dependent on the employed transmission technique as well as the distribution of users and base stations, the varying channel conditions, and the varying connections or association between users and base stations. Traditional networks at lower frequencies usually employ omni-directional transmission which causes an (almost) equal amount of interference in any direction. mmWave transmission requires beamforming which is highly directional and drastically changes the interference structure in the network. We examine realistic interference power distributions in a mmWave network employing beamforming transmission under different user association schemes, and contrast with those under omni-directional transmission. Numerical results using analytical mmWave channel models and measurement-based NYUSIM channel generator show that not only beamforming reduces the amount of strong interference in the network and hence significantly enhances the throughput, but also user association can considerably alter network interference and throughput structures.

11:40 ***Coexistence Testing of 5G with Radar/Satellite...N/A***

Raymond Shen (Keysight Technologies, USA)

As the frequency spectrum becomes more crowded, allocated communications frequencies are now overlapping each other, giving birth to the term "coexistence". For example, in the 3.5 GHz band in the US, 4G LTE and military radars may disrupt each other. Being that 5G will be in operation together with many other transmitters, including radars, radios, satellite, or others, a test platform is needed to assess vulnerabilities in specific use cases/venues. How vulnerable a 5G comms system is to unintentional interference or intentional jamming is a subject of concern. Here, we describe a series of signal generation systems to simulate real world scenarios, including terrain propagation effects. We also describe signal analyzer systems to characterize the effects of interference on signal quality of the communications system.

12:00 ***User-Centric Approaches for Next-Generation Self-Organizing Wireless Communication Networks Using Machine Learning...672***

Chetana V Murudkar and Richard D. Gitlin (University of South Florida, USA)

With the ever-increasing rise of a wide range of data-driven applications and services, as well as the synergies of gigabit wireless connectivity and pervasive broadband connectivity, there is a need for a paradigm shift in network methodologies to develop and deploy networks, such as 5G wireless. User-centric approaches to implementing self-organizing networks (SON) using machine learning (ML) have the potential to address the above challenges for 5G wireless communications networks and provide a seamlessly connected eco-system with superior user experience. This paper focuses on the potential performance improvements that can be achieved by integrating self-organizing networks and machine learning using user-centric approaches, with a focus on self-healing and self-optimizing SON functions.

12:20 ***An Investigation of Flexible Waveform Numerologies for 5G V2I Cellular Networks from a Physical Layer Perspective...678***

Viktor Stoynov, Dimitriya Mihaylova, Zlatka Valkova-Jarvis, Georgi Iliev and Vladimir K. Poulkov (Technical University of Sofia, Bulgaria)

In the context of 5th generation (5G) wireless networks, the overall performance improvement together with excellent levels of user experience/satisfaction and a variety of intelligent services are of great importance. The physical layer implementation, and in particular the waveform schemes and modulation techniques, need to offer sufficient flexibility, high interference immunity, efficient spectrum utilization, reduced Out-of-Band (OOB) emissions etc. This is especially important in high mobility scenarios such as Vehicle-to-Infrastructure (V2I) communications in Ultra Dense Networks (UDN). In this paper, the effects on downlink communication of different waveforms based on Orthogonal Frequency Division Multiplexing (OFDM) using distinct numerology settings are compared. Several scenarios are introduced that take into account the impact of channel delay spread and the speed of User Equipment (UE) movement in attaining higher vehicular UDN network performance. Finally, this work's research findings on the advantages and drawbacks of using flexible numerology-based waveform approaches in vehicular UDNs are summarized.

12:40 ***Intrusion Detection System Model Implementation against DDOS attacks...684***

Maria Nenova and Kiril Kassev (Technical University of Sofia, Bulgaria)

An implementation of intrusion detection systems (IDS), its architectures, and detection methods are investigated. It is performed SNORT bandwidth traffic analysis in IDS and IPS systems. The main requirements for Installation and configuration of the system are also discussed. Then the configuration of the firewall policy and specifics there, are also presented. It is also described the database structure, the operating modes, and analysis of the rules. At the end is suggested solution.

Wednesday, November 6 14:20 - 16:10

RCS: Scattering and Diffraction

Room 3

Chairs: Raphael Kastner (Tel Aviv University, Israel), Piergiorgio L.E. Uslenghi (University of Illinois at Chicago, USA)

14:20 ***Exact Geometrical Optics Scattering by Metallic Structures with Sharp Edges Subjected to Multiple Plane Waves Illumination...N/A***

Piergiorgio L.E. Uslenghi (University of Illinois at Chicago, USA)

Several metallic structures consisting of planar surfaces with sharp edges are considered. It is shown that under excitation by a selected number of plane waves having appropriate amplitude, phase, polarization and direction of incidence, geometrical optics yields the exact solution to the scattering problem.

14:50 ***RCS Resonances for Canonical Structures...688***

Yury Shestopalov (University of Gävle, Sweden)

A brief survey is presented on the methods aimed at rigorous validation of the occurrence of complex RCS resonances for canonical structures: dielectric and perfectly conducting cylinders covered by layered media possessing circular symmetry. It is shown that the resonances are associated with singularities of the scattered field in the complex domain.

15:10 ***Method of Total Fields for Diffraction Problems between Different Media...690***

Husnu Deniz Basdemir (Cankaya University, Turkey)

Method of Total Fields for Diffraction Problems between Different Media

15:30 ***Reactive Surfaces as Half-Duals of PECs/PMCs...694***

Raphael Kastner (Tel Aviv University, Israel)

A dual electromagnetic problem can be described as a 90 degree rotation of another problem around the axis of propagation for each spectral (plane wave) component. The operator responsible for this rotation is the curl which is the essence of Maxwell's equations. Using duality, one can apply a certain solution, e.g., scattering from a PEC, to another problem, such as scattering from a PMC. Here, this idea is expanded to accommodate half-curls such that a wilder range of problems, including reactive surfaces, is attainable from the solution of a PEC/PMC problem. This would eliminate the need to solve the reactive surface problem separately.

15:50 ***Depolarization Diversity...698***

Alan Frid (Shamoon College of Engineering, Israel); Yehuda Ben-Shimol (Ben-Gurion University of the Negev, Israel); Nathan Blaunstein (Ben-Gurion University of the Negev, Beer-Sheva, Israel)

Depolarization of EM waves in terrestrial communication links has been poorly researched. The main source of knowledge to this field comes from Stokes parameters and various field tests results. This paper presents an innovative analytical approach to this topic, providing a sufficient way of predicting the polarization of EM waves. This can be used to reduce polarization losses in receiving antennas, hence, more effective data transmission can be achieved. This paper makes use of the waves total intensity and derives probability functions for parameters of the spatial polarization ellipse.

WPT: Wireless Power Transfer

Room 4

Chair: Vadim Issakov (Infineon Technologies AG, Germany)

14:20 ***Metasurface for Wireless Power Transfer to Multiple Receivers...704***

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

In this paper we present a metasurface for wireless power transfer system. The metasurface supports a surface wave, which greatly enhances the power transfer distance. In this way, WPT efficiency of 80% to a single receiver is obtained at a distance 80 cm. In addition, we show that an efficient power transfer to multiple receivers is possible. An overall efficiency of 82% can be obtained at the distance of 45 cm.

14:50 ***An RF Voltage Detector with Low Harmonic Feedback for Antenna Tuning Switches...706***

Oguzhan Oezdamar (University of Erlangen-Nuremberg, Germany); Amelie Hagelauer (University of Bayreuth, Germany); Robert Weigel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Valentyn Solomko (Infineon Technologies, Germany)

A voltage detector with reduced harmonic feedback into the sensed RF path for the use in highly-linear, highvoltage antenna tuning switches is demonstrated. The reduction of harmonic content is achieved by adding linearization elements to the charge-pump-based rectifier, which are activated at large input RF voltage amplitudes. The detector has been implemented and tested in hardware with two high-voltage switches. The ICs were manufactured in Infineon 130nm RF switch process. The measured voltage detector exhibits a linear transfer characteristic and generates feedback harmonics level, which is below the nonlinearities of the intrinsic RF switch. The proposed detector targets voltage monitoring function, particularly in the RF switches for antenna tuning applications.

15:10 ***Practical Issues with Unloaded Resonant Inductive WPT Link Operating in Load-Independent Regime...711***

Yotam Frechter and Yegal Darhovsky (BGU, Israel); Alon Kuperman (Ben-Gurion University of the Negev, Israel)

The paper reveals practical issues present in series-series compensated unloaded inductive wireless power transfer system operating in load-independent regime. It was recently shown, that due to existence of parasitic resistances, corresponding output voltage is not completely load-independent. Based on time-domain analysis, DC voltage gain of an unloaded system was predicted for a wide range of operation frequencies. However, parasitic lumped capacitance of the receiving coil was not taken into account. It is therefore shown that parasitic oscillations appearing in an unloaded secondary impose significant overvoltage at DC output, which may cause safety issues. Two possible solutions are discussed, allowing damping the oscillations thus making the unloaded operation feasible. The presented analysis is well-verified by simulation results and experiments of a 400V, 1kW inductive wireless power transfer link.

15:30 ***Efficient Modeling of DC- RF module of Space Solar Power Satellite with Improved Antenna design and Metasurface...716***

Amit Baghel and Shashank Kulkarni (IIT Guwahati, India); Sisir Kumar Nayak (Indian Institute of Technology Guwahati, India)

In this paper the efficient modeling of DC-RF module of space solar power satellite (SSPS) with improved antenna design and metasurface is proposed. With the higher losses as one of the present problem in the DC-RF conversion, using single phase full-bridge topology with a maximum power point tracking algorithm is proposed. The design parameters of the various components of the proposed system is calculated. The control and efficiency of DC-RF conversion with the proposed system is simple as compared to DC-RF converters as of now. Also, to increase the power transfer efficiency, the proposed antenna with the metasurface is used which helps to increase the received power by 79% compared to the conventional antenna. The system if scaled up with the proposed proof of concept can help in efficient SSPS programs in future.

15:50 ***Square Slotted Patch Antenna for 2.45 GHz Far-field Wireless Power Transfer...720***

Shashank Kulkarni and Amit Baghel (IIT Guwahati, India); Sisir Kumar Nayak (Indian Institute of Technology Guwahati, India)

A square slotted patch antenna for far-field wireless power transfer applications is presented. The antenna has compact size equal to 0.416 lambda X 0.236 lambda X 0.013 lambda which can be fit into most of the devices. It exhibits a total of 780 MHz of -10 dB impedance bandwidth in S-band with good directional characteristics. A maximum of 1.24 dB gain is observed with 1.025 dB at 2.45 GHz. A prototype of the antenna is fabricated and tested for S-band with good agreement between measured and simulated results. A computed study for far field WPT based on Friis transmission equation is presented for double ridged guide and parabolic profile horn as transmitting antennas.

PT4: Packaging & Thermal Management 4

Room 5

Chairs: David Ratner (Rafael, Germany), Gennady Ziskind (Ben-Gurion University of the Negev, Israel)

14:20 ***Thermal Management of Heterogeneous Microsystems...N/A***

Yogendra Joshi (Georgia Institute of Technology, USA)

With the recent end of the International Technology Roadmap for Semiconductors, which has guided research on thermal packaging of microprocessors for nearly a quarter century, significantly different challenges are on the horizon for compact, high performance microsystems. Heterogeneous integration through chip stacking promises to bring in multiple system functionalities such as logic, memory, and radio frequency in highly compact form factors, along with great challenges to thermal management. I will discuss recent and ongoing computational and experimental research on microfluidic cooling and sub-mm vapor chambers to address the high heat fluxes, and localized hot spots in these applications.

14:50 ***CVD Diamond Films for Thermal Management Applications...724***

Shusmitha Kyatam and Debarati Mukherjee (Instituto de Telecomunicações, Portugal); Armindo Silva (Universidade de Aveiro, Portugal); Luis Nero Alves (DETI, Universidade of Aveiro, Instituto de Telecomunicações & Instituto de Telecomunicações, Portugal); Shlomo Rotter (Smart Diamond Technologies, Lda, Portugal); Miguel Neto, Filipe Oliveira and Rui Silva (University of Aveiro, Portugal); Hugo Neto (PICadvanced, Portugal); Joana C Mendes (Instituto de Telecomunicações, Portugal)

One of the stringent issues in modern electronic applications is related with the necessity of keeping the operating temperature of electronic components within safe levels. The use of passivation, board, and encapsulation materials with large thermal conductivity provides an efficient way of removing the excess heat without increasing the volume and weight of the electronic circuitry. Following this trend, diamond films deposited by chemical vapor deposition (CVD) offer a simple and efficient solution to maintain the operating temperature within safe limits. This paper discusses the use of CVD diamond films with HEMT devices, photonic integrated circuits and high power LEDs.

15:10 ***Supercritical CO2 as cooling fluid for high power devices...N/A***

Anatoly Parahovnik and Yoav Peles (University of Central Florida, USA)

The ever increasing demand for better approaches to cool high power electronics, such as GaN, radar systems, and supercomputers, has been a main research and development effort carried out by the thermal management community. Here we report on a relatively new cooling approach using carbon dioxide (CO2) in a 300 μm hydraulic diameter microchannels at its supercritical state. A dedicated micro device with embedded heaters and resistance temperature detectors (RTD) was micro fabricated and integrated into a high-pressure experimental apparatus that enabled precise control and measurements of temperature, pressure, and mass flux. Flow visualization through a high-speed camera and a microscope complemented the measurements. Different flow patterns were observed at different mass fluxes. An overall heat transfer coefficient (h) ranging from 0.5 to 1.9 kW/m2K was obtained at different locations inside the microchannel. The pressure drop was significantly lower than that of water for the same mass flux.

15:30 ***Enhancing the Efficiency of Electronic Cooling Devices by Bio-coatings...730***

Ali Kosar, Veysel Kaya and Ozlem Kutlu (Sabanci University, Turkey)

Boiling is considered as one of the effective cooling methods in electronics devices because of its high heat removal capability. One of the promising techniques for boiling heat transfer enhancement is surface modification. Here, we propose a novel method for surface enhancement via crenarchaeon Sulfolobus Solfataricus P2 bio-coating. Unlike the available surface modification techniques, which require expensive microfabrication devices (physical modifications) and have damaging impact on the environment (chemical modifications), the proposed coating is cheap, scalable and most importantly is biocompatible with no environmental toxicity. Flow boiling experiments were performed in a high aspect ratio microchannel . Experiments were performed under atmospheric pressures, where distilled water was used as the working fluid. To examine the effect of coating, flow boiling tests were performed at mass fluxes ranging from 50 to 150 kg/m2s on surfaces with two different thicknesses. A bare silicon surface was tested as reference. High speed camera was employed for analyzing the results in the flow boiling set-up. The obtained results indicated that the coated layer creates a porous structure with numerous pores, acting as nucleation sites during boiling and delay the critical heat flux (CHF) condition. This study clearly represents the potential of surfaces with bio-coatings to obtain substantial energy saving and efficiency in electronics cooling devices.

15:50 ***Intel First Coreless Package Qualification...N/A***

Roman Rechter (Intel Corporation, Israel)

Package form factor is crucial for chips targeted towards ultra-low power devices. The 6th Generation of Intel ultra-low power processors, introduced new coreless package. Initially package main parameters included: 1) coreless substrate 2) 270um thin die with) 3) plastic frame for warpage improvement. However, this package suffered from high warpage and poor SMT yields. Moreover, plastic process caused surface defects leading to die cracks. Eventually package development was dropped and new package was developed. Main differences described herein: 1) thicker die with thickness of 370um 2) stainless frame for warpage improvement, stiffener. This configuration was able to satisfy manufacturability requirements, however during package development multiple quality and reliability issues were discovered, such as stiffener delamination, electrical crosstalk, trace cracks, die cracks and more. This paper presents an overview of the fail modes and the technological solutions implemented.

UA3: Short Course: Unconventional Array Design 3

Room: Royal H

T6: Stability Analysis of Microwave Circuits

Room: Royal I

Instability is a fundamental problem in the design of microwave circuits, giving rise to an experimental behaviour qualitatively different from the expected one, which will degrade or fully disrupt the circuit performance.

14:20 ***Stability analysis of microwave circuits...N/A***

Almudena Suarez (University of Cantabria, Spain)

Instability is a fundamental problem in the design of microwave circuits, giving rise to an experimental behaviour qualitatively different from the expected one, which will degrade or fully disrupt the circuit performance.

SP3: Signal Processing & Imaging 3

Room: Royal J

Chairs: Sergey Ivashov (5, 2nd Baumanskaya str., Russia & Bauman Moscow State Technical University, unknown), Luiz Kretly (UNICAMP, Brazil)

14:20 ***Submillimeter-wave Imaging: Applications and Technologies...N/A***

Erich Grossman (NIST, USA)

Imaging at submillimeter wavelengths (expansively interpreted as 3 - 0.1 mm) has been under development for at least 30 years, but has yet to blossom into a true "industry" in the way that infrared imaging did in the 1990's. Technology developers often attribute this to the lack of a "killer application", while organizations seeking to apply submm imaging often attribute it to lack of an ideal technology solution. Both viewpoints have merit, and they intersect on the question of cost. In this presentation I will discuss some of the submm imaging applications I have encountered over many years of work in the field, both "niche" and potentially large-scale applications. Their common thread is the need to form images through some type of obscurant, whether that be clothing, atmospheric dust and fog, or manmade coatings. I'll then describe some of the technology solutions that have been developed for submm imaging, focusing on more recent efforts, and touching briefly on some of the published work done in my lab at NIST on bolometers, bolometer arrays, scattering phenomenology, and structured illumination imaging.

14:50 ***Machine Learning for Detecting Anomalies in SAR Data...732***

Yuval Haitman, Stanley R. Rotman and Itay Berkovich (Ben-Gurion University of the Negev, Israel)

One of most common algorithms for anomaly detection in multi-dimensional imagery is the Reed - Xiaoli (RX) algorithm; it gives each pixel a score that defines its likelihood to be an anomaly. We have implemented a new algorithm which uses both RX and the Non-Negative Matrix Factorization (NNMF) learning algorithm in order to pick an adaptive threshold for detection; we have applied it to Synthetic Aperture Radar (SAR) data. The NNMF approach is defined as a minimization problem which approximates the given data by extracting its main trends. By comparing the original data to the reduced data, we can divide the image anomalies into two different groups, where one group contains the anomalies which are part of the image main trends and the second group contains the anomalies of the sub trends. With this division, we can pick an adaptive threshold for each of the groups according to its unique characteristics.

15:10 ***Detection of Water Inclusions in Honeycomb Composite Products by a Holographic Radar...737***

Sergey Ivashov (Bauman Moscow State Technical University, Russia); Margarita Chizh (Bauman Moscow State Technical University & Remote Sensing Laboratory, Russia); Andrey Zhuravlev and Vladimir Razevig (Bauman Moscow State Technical University, Russia)

Detection of water inclusions in honeycomb composites is an urgent task during construction and operation of various aircrafts. This includes diagnostics of helicopter composite rotor blades, since the presence of moisture condensed in the internal air cavities leads to gradual development of cracks and results in blade deterioration, icing and imbalance. The imbalance of helicopter rotor blades may influence the comfort and safety of a flight, result in thrust loss and increased load in dynamic components caused by the helicopter vibration. Currently, restoring balance is a complex and time-consuming procedure under the operating conditions of a helicopter. This paper presents the results of detecting moisture inside the honeycomb structure of the blades using microwave holography, which can be used to simplify and speed up the procedure for their diagnosis and prevent imbalance.

15:30 ***A Variable Step Perturb and Observe Algorithm for Maximum Power Point Tracking Based on Modified Newton-Raphson Method...N/A***

Jorge Carvalho (University of Campinas, Brazil); Luiz C. Kretly (Unicamp, Brazil)

This work presents a derivation of the Newton-Raphson method, treated here as Quasi-Newtonian (QN) algorithm. The QN has the same proprieties of the traditional Newton-Raphson method for extremes seeking, but due to a different manipulation of the Taylor series expansion, the method becomes a second order method instead of a first order method. Hence acquiring a fast convergence. That characteristic is explored in the performance of the Perturb and Observe algorithm for maximum power point tracking of photovoltaic systems. At this work, the QN is used not only to analyze the slope of the PxV curve of the photovoltaic system in order to choose the perturbation direction inserted by the Perturb and Observe algorithm (P\&O) but to calculate the value of the perturbation as well. The simulation results have shown a fast-tracking of the maximum power point (MPP) and a small steady-state error when compared to the classical P\&O algorithm.

15:50 ***Comparison of Different NDT Methods in Diagnostics of Rocket Cryogenic Tanks Thermal Protection Coating...742***

Sergey Ivashov, Vladimir Razevig and Andrey Zhuravlev (Bauman Moscow State Technical University, Russia); Timothy Bechtel (Franklin & Marshall College, USA); Margarita Chizh (Bauman Moscow State Technical University & Remote Sensing Laboratory, Russia)

Accidents during spacecraft launching quite often occur in different countries. They cause considerable direct material losses and indirect losses in the form of increased premiums for the insurance of subsequent launches. One of the means to improve reliability of the rockets is the non-destructive testing of the manufactured products. This paper focuses on introduction of a new holographic subsurface radar technology as a nondestructive testing technique of dielectric materials and comparison of this technology with X-ray and ultrasonic methods.

Wednesday, November 6 16:20 - 17:30

KN3: Plenary Keynote Presentations 3

Rooms: Royal H, Royal I, Royal J

16:20 ***Velocity tomography imaging and tumor treatment planning...N/A***

Avraham Suhami (Elscint, Israel)

Velocity Tomography basically follows from the Maxwell equations and the theory of Relativity, where it can be shown that the phase Velocity of an Electromagnetic wave V propagating in the human body, is given at high GHz frequencies, where the permittivity εr is much larger than the conductivity (σ), by V ~ C0/(εr)1/2 where C0 is the light velocity. For example as the permittivity of a malignant tumor at 3 GHz is ~60 the "inverse velocity" of an RF beam traversing a malignant tissue, is 25psec/mm. Consequently what Velocity Tomography says is that the nature of a body tissue, whether normal, benign or malignant can be quantified by measuring "Traversal Time" as "Time" can be measured with extremely high accuracies.

16:55 ***Wireless Century Perspective: 5G/IoT (Internet of Things) and a Vision for 6G/IoE (Internet of Everything)...N/A***

Richard D. Gitlin (University of South Florida, USA)

This presentation provides a perspective on the emerging Wireless Century driven by the introduction of 5G/IoT networks and expectations for 6G /IoE wireless networking. It is expected that the fifth generation (5G) of mobile communications will impact our life more than any previous wireless technology by enabling a seamlessly connected society that brings together people, data, and "things" via a myriad of new applications and technologies. This presentation will focus on several research challenges and foundation technologies needed to meet the ambitious 5G/IoT application requirements for broadband networking, low-latency applications [e.g., autonomous vehicles] technologies, and Internet of Things (IoT) scenarios such as Machine-to-Machine (M2M) networking. Technology emphasis will be on the central role of Machine Learning (ML) and Artificial Intelligence (AI) in optimizing the latency and throughput of cell-less and edge-based ("Fog") network architectures, synchronization of mmWave networks, novel MAC and NOMA [non-orthogonal multiple access] signal processing for increased throughput in M2M communications, and enabling near-instant recovery from link or nodal failures. Several contemplated revolutionary 6G/IoE applications will be briefly discussed including selfsustaining networks, 3-D systems (ground and aerial users), smart cities, extended reality, cyber-physical networking of wearable and in vivo bio-medical devices, wireless brain-computer interactions, and connected autonomous systems (e.g., drones, robots). Selected foundation technologies envisioned to realize these application will also be presented including: edge AI, large intelligent surfaces, and 3D networking.

Wednesday, November 6 17:30 - 18:00

CL: Closing Plenary Session

Rooms: Royal H, Royal I, Royal J