MTT-S Winter Technical Meeting
Distinguished Microwave Lectures
Rosen Plaza Hotel, Orlando, Florida
Salon 13 & 14
Saturday January 19, 2019, 1:00pm – 3:00pm

The Winter Technical Meeting provides a forum for MTT-S Members and others to preview the Distinguished Microwave Lectures (DML) by the newly elected Distinguished Microwave Lecturers of Class 2019-2021. Everyone is welcome to attend the talks.

Chair: J.l C. Chiao, Southern Methodist University Co-host: IEEE MTT/AP Orlando Chapter

1:00pm – 1:40pm	**Dr. Ho-Jin Song** **Pohang University of Science and Technology** **Terahertz Communications at 300 GHz: Devices, Packages and System**
1:40pm – 2:20pm	**Dr. Payam Heydari** **University of California, Irvine** **Fundamentals of mm-Wave and Sub-Terahertz Frequency Generation, Synthesis, and Radiation for Multi-Antenna Array Transceivers**
2:20pm – 3:00pm	**Dr. Edward Ackerman** **Photonic Systems, Inc.** **Analog Photonic Systems: Features & Techniques to Optimize Performance**

Dr. Ho-Jin Song
Pohang University of Science and Technology
Terahertz Communications at 300 GHz: Devices, Packages and System

Recent progress in semiconductor devices on compound semiconductor or silicon substrates has made it possible to produce more power and receive a signal with less noise at THz frequencies. Various integrated circuits for the THz radio front-end functional blocks, including power and low-noise amplifiers, modulators and demodulators, and oscillators, have been demonstrated in the last decade. In the first experimental demonstration conducted in 2004, bulky instruments originally developed for THz spectroscopy were used to transmit pulsed THz signals carrying a 7-kHz bandwidth audio signal across a short free space. However, recently, there have been several successful demonstrations of multi-Gbps data transmissions at THz frequencies with state-of-the art devices and components. In this talk, the first prototype of a THz wireless communications system designed under the 'touch-and-go' scenario will be presented. I clarify the concept of the KIOSK data downloading system, cover some considerations in this work, and present a brief link-budget plan. We will then overview technologies for implementing THz components operating at 300 GHz and their performance, followed by preliminary investigation of the channel responses and the experimental demonstration results. At the end of the presentation, we will discuss several issues that need to be addressed for the future of the THz communications systems, in terms of system architectures, packaging and potential applications.

Ho-Jin Song received the B. S. degree in electronics engineering from Kyungpook National University, Daegu, Korea in 1999, and the M.S. and Ph.D. degree in electrical engineering from Gwangju Institute of Science and Technology (GIST), Gwangju, Korea, in 2001 and 2005, respectively. Since he joined Nippon Telegraph and Telephone, Japan which is the third largest telecommunication company in the world in 2006, he had engaged in the development of sub-millimeter and terahertz wave devices, circuits and systems for communication, remote sensing and imaging applications. In 2015, he was named to a distinguished research scientist of NTT Labs in 2015. Since 2016, Dr. Song has been with the department of Electrical Engineering, Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea. His current research interest includes mm-wave and terahertz circuits, antenna, packages and test-bed systems, particularly for wireless communication, connectivity and radar applications. Dr. Song was a recipient of GIST Best Thesis Award (2005), NTT Microsystem Labs Research of the Year Award (2009 and 2014), Young Scientist Award of Spectroscopical Society of Japan (2010), IEEE Microwave and Wireless Component Letters Tatsuo Itoh Best Paper Award (2014) and Best Industrial Paper Award at IEEE MTTs-IMS 2016 (2016). He is a senior IEEE member and an IEEE distinguished microwave lecturer for the 2019-2021 term.

Dr. Payam Heydari
University of California, Irvine
Fundamentals of mm-Wave and Sub-Terahertz Frequency Generation, Synthesis, and Radiation for Multi-Antenna Array Transceivers

Operation in the mm-wave and terahertz (THz) bands has gained great interest due to abundance of unutilized spectrum and resurgence of new applications in wireless/cellular communications, most notably 5G. If combined with spectrally efficient (de-)modulation techniques, mm-wave/THz wireless communication has the potential to achieve multi-gigabit-per-second wireless data-rate. In addition, the operation at higher frequency gives rise to smaller size passive components (most notably antennae), making it possible to design and implement massive phase-array or MIMO systems on a single die or single wafer. As the communication schemes including spectrally-efficient (de-)modulation and carrier aggregation techniques are making progress at RF frequencies, far more challenging requirements will be imposed on the oscillator and frequency synthesis design. Increasing the carrier frequency towards the mm-wave/terahertz regime only makes these requirements more stringent.

These seminar series cover two generic inter-related themes, namely (1) a comprehensive overview of mm-wave multi-antenna transceiver architectures which includes phased-array, MIMO, and beam-forming MIMO architectures; (2) a general, yet in depth, overview of frequency generation, synthesis, and high-efficiency radiation at mm-wave and sub-terahertz frequencies.

Topics to be covered in each seminar are selected from the following items: (1) Fundamentals of multi-antenna architectures enabling beam-forming, diversity, and spatial multiplexing. (2) Overview of front-end design for multi-antenna transceivers including RF phase-shifting, LO phase-shifting, and array coupled of oscillators. (3) The fundamentals of oscillator design at mm-wave/sub-terahertz frequencies. (4) Overview of several oscillator topologies (which are amenable to high frequencies) including modified Clapp, double-stacked cross-coupled pair, inductive tuning, and varactor tuning with loss compensation. (5) A new perspective and design philosophy of mm-wave/THz frequency synthesizer design for the purpose of maximizing output power and frequency tuning and minimizing phase-noise. (6) An in-depth overview of techniques and architectures facilitating very high efficiency, high power and low noise radiation using novel on-chip multi-port oscillators incorporating new on-chip high-Q passive structures.

Payam Heydari received his B.S. and M.S. degrees (Honors) in Electrical Engineering from Sharif University of Technology in 1992 and 1995, respectively. He received his Ph.D. degree from the University of Southern California in 2001. He is currently a Full Professor of Electrical Engineering at the University of California, Irvine.

His research covers the design of terahertz/millimeter-wave/RF and analog integrated circuits. He is the (co)-author of two books, one book chapter, and more than 140 journal and conference papers. He has given Keynote Speech to IEEE GlobalSIP 2013 Symposium on Millimeter Wave Imaging and Communications, served as Invited Distinguished Speaker to the 2014 IEEE Midwest Symp. on Circuits and Systems, and gave a Tutorial at the 2017 International Solid-State Circuits Conference

(ISSCC). He has served as Distinguished Lecturer of both the IEEE Solid-State Circuits Society (SSCS) (2014-2016) and the IEEE Microwave Theory and Techniques Society (MTT-S) (2019-2022).

Dr. Heydari is the recipient of the 2016-2017 UCI School of Engineering Mid-Career Excellence in Research, the 2014 Distinguished Engineering Educator Award from Orange County Engineering Council, the 2009 Business Plan Competition First Place Prize Award and Best Concept Paper Award both from Paul Merage School of Business at UC-Irvine, the 2010 Faculty of the Year Award from UC-Irvine's Engineering Student Council (ECS), the 2009 School of Engineering Fariborz Maseeh Best Faculty Research Award, the 2007 IEEE Circuits and Systems Society Guillemin-Cauer Award, the 2005 IEEE Circuits and Systems Society Darlington Award, the 2005 National Science Foundation (NSF) CAREER Award, the 2005 Henry Samueli School of Engineering Teaching Excellence Award, and the Best Paper Award at the 2000 IEEE Int'l Conference on Computer Design (ICCD). He was recognized as the 2004 Outstanding Faculty in the EECS Department of the University of California, Irvine. His research on novel low-power multi-purpose multi-antenna RF front-ends received the Low-Power Design Contest Award at the 2008 IEEE Int'l Symposium on Low-Power Electronics and Design (ISLPED). The Office of Technology Alliances at UCI has named Dr. Heydari one of 10 Outstanding Innovators at the university.

Dr. Heydari is currently a member of International Technical Program Committee of the International Solid-State Circuits Conference (ISSCC), an Associate Editor for the IEEE Solid-State Circuits Letters (SSC-L), and a member of AdCom for the IEEE Solid-State Circuits Society. He has served as the Guest Editor of IEEE Journal of Solid-State Circuits (JSSC), and Associate Editor of IEEE Trans. on Circuits and Systems - I. He is an IEEE Fellow for contributions to silicon-based millimeter-wave integrated circuits and systems.

Dr. Edward Ackerman
Photonic Systems, Inc.
Analog Photonic Systems: Features & Techniques to Optimize Performance

Both the scientific and the defense communities wish to receive and process information occupying ever-wider portions of the electromagnetic spectrum. This can often create an analog-to-digital conversion "bottleneck". Analog photonic channelization, linearization, and frequency conversion systems can be designed to alleviate this bottleneck. Moreover, the low loss and dispersion of optical fiber and integrated optical waveguides enable most of the components in a broadband sensing or communication system, including all of the analog-to-digital and digital processing hardware, to be situated many feet or even miles from the antennas or other sensors with almost no performance penalty. The anticipated presentation will highlight the advantages and other features of analog photonic systems (including some specific systems that the author has constructed and tested for the US Department of Defense), and will review and explain multiple techniques for optimizing their performance.

Edward I. Ackerman received his B.S. degree in electrical engineering from Lafayette College in 1987 and his M.S. and Ph.D. degrees in electrical engineering from Drexel University in 1989 and 1994, respectively. From 1989 through 1994 he was employed as a microwave photonics engineer at Martin Marietta¹s Electronics Laboratory in Syracuse, New York, where he used low-loss narrowband impedance matching techniques to demonstrate the first amplifierless direct modulation analog optical link with RF gain (+3.7 dB at 900 MHz). From 1995 to July 1999 he was a member of the Technical Staff at MIT Lincoln Laboratory, where he developed high-performance analog photonic links for microwave communications and antenna remoting applications. During this time he achieved the lowest noise figure ever demonstrated for an amplifierless analog optical link (2.5 dB at 130 MHz). While at Lincoln Laboratory he also developed and patented a novel linearization technique that uses a standard lithium niobate modulator with only one electrode to enable improved analog optical link dynamic range across broad bandwidths and at higher frequencies than other linearization techniques currently allow. Since 1999 he has been Vice President of R & D for Photonic Systems, Inc. of Billerica, Massachusetts. He has co-edited a book and has authored or co-authored three book chapters as well as more than 70 technical papers on the subject of analog photonic subsystem performance modeling and optimization. Dr. Ackerman is a Fellow of the IEEE. He holds eight US patents.