22nd January, 2025
San Juan | Puerto Rico

WORKSHOP PROGRAM

ARFTG-104 Workshop

Testing, Modeling and Linearization
of Nonlinear RF/microwave Devices and Circuits

W-1

8:00-8:45

Definition of NPR, EVM, and EVM-like criterion for use in linear distortion, nonlinear distortion and noise characterization

Jacques Sombrin (CNES, France)

NPR, EVM, and EVM-like criterion can be defined in the same way by using cross-correlation to discriminate between ideal signal and noise or distortion. After removing the ideal signal from the distorted and noisy signal, it is possible to interpret the residual noise or distortion to obtain data on the equipment in the transmission link and in some cases to improve its operation. Some well known degradations are caused by nonlinear transfer curves of amplifiers, additive noise, phase noise of local oscillators, phase and amplitude imbalance of quadrature modulators and demodulators, frequency response of filters, ... One final goal is to optimize the energy consumed to transmit each bit of information in a given noisy channel.

Jacques Sombrin received his engineering degrees from Ecole Polytechnique (Paris) in 1969 and Ecole Nationale Supérieure des Télécommunications (Paris) in1974. He is a life member of IEEE, emeritus member of SEE and member of EuMA. He was awarded the EuMA Career Award in 2015. Microwave Engineer in CNES (the French Space Agency) from 1974, more recently Senior Expert and Assistant Director for Radio Frequencies, in charge of radio frequency research program and roadmaps until 2010. He participated in satellite projects and has been responsible for microwave equipment development (TWT, TWTA, filters...), for microwave instruments and payloads, for space telecom systems architecture and performance. Since 2011, he is a Consulting Engineer and a researcher in TéSA (Aeronautics and Space Telecommunications laboratory in Toulouse). His current research interests include: • Model and simulation of amplifiers nonlinearity in telecommunication satellites and their linearization. • Telecommunication systems NPR and EVM characterization, efficiency, and optimization of capacity/power consumption compromise. • Multipactor effect, microwave breakdown and passive intermodulation products.

W-2

8:45-9:30

Advances in Characterization and Linearization of RF Power Amplifiers for Modulated Applications

Gian Piero Gibiino (University of Bologna, Italy)

This presentation addresses recent research on the characterization and linearization of RF power amplifiers (PAs) targeting modulated operation, with a primary emphasis on Gallium Nitride PAs for space and communications applications. Wideband active load-pull techniques are employed to evaluate the tradeoff between linearity and efficiency at the device level. The talk also presents a case study on a dual-input MMIC Doherty PA operating at 24 GHz, where optimization techniques are used to automatically adjust bias and input splitting to improve efficiency while maintaining linearity for high-PAPR modulated signals.

Gian Piero Gibiino received a dual Ph.D. degree from the University of Bologna, Bologna, Italy, and KU Leuven, Leuven, Belgium, in 2016. That same year, he was a visiting researcher at Keysight Technologies, Aalborg, Denmark. He is currently an Assistant Professor at the University of Bologna, where he conducts research in the fields of microwave measurements and nonlinear modeling. Dr. Gibiino is also an Affiliate Member of the MTT-S Design Automation and Microwave Measurements Technical Committees.

W-3

9:30 – 10:15

Physics-Based Nonlinear Modeling of GaN HEMTs using the ASM-HEMT and Fermi Kinetics Transport

Nicholas Miller (Michigan State University)

Rapid design and prototyping of next-generation microwave and mm-wave GaN technology requires reliable and accurate models. A paramount component of enabling first-pass design success of GaN microwave power amplifiers is the ability to model the various applications and properties of the GaN transistors. This talk will focus on the recent developments of nonlinear modeling of GaN HEMTs using the ASM-HEMT and the Fermi kinetics transport TCAD solver.

Nicholas C. Miller (Senior Member, IEEE) received the B.S., M.S., and Ph.D. degrees in electrical and computer engineering from Michigan State University, East Lansing, MI, USA in 2013, 2015, and 2017, respectively. He was an electronics engineer at the Air Force Research Laboratory from 2017 to 2023. In 2023, he joined the faculty of the Electrical and Computer Engineering Department at Michigan State University as an assistant professor. He is currently a young professional member of the IEEE MTT TC-3 microwave measurements committee. His current research interests include linear and nonlinear mm-wave characterization of on-wafer transistors and integrated circuits, physics-based compact modeling of compound semiconductor transistors, and technology computer aided design modeling of wide and ultrawide bandgap semiconductor transistors. Dr. Miller was the recipient of the IEEE AP-S pre-doctoral research Award in 2013, U.S. DoD science, mathematics, and research for transformation (SMART) scholarship in 2014, IEEE Dayton Section Harrell V. Nobel Award in 2019 for physics-based device modeling, Best Conference Paper Award at the 21st IEEE Wireless and Microwave Technology Conference (WAMICON) in 2021, the Best Presentation Award at the IEEE MTT-S Young Professional Workshop on Optimization and Modeling of Active Devices in 2022, and the AFRL Early Career Award in 2023.

W-4

10:30 – 11:15

Load Modulated Balanced Amplifier: Design and Operation

Taylor Barton, Yaqub Mahsud (University of Colorado Boulder)

The load modulated balanced amplifier architecture for efficiency enhancement has received a lot of recent attention in the literature, with a variety of drive strategies (e.g., LMBA vs S-LMBA) and design techniques proposed. In this talk, we will present the LMBA design space and give design examples comparing the effects of different strategies on efficiency, linearity, and bandwidth. The hardware examples will focus primarily on MMIC implementations of the LMBA architecture.

Prof. Taylor Barton is an Associate Professor in the Department of Electrical, Computer, and Energy Engineering at the University of Colorado Boulder. She received her degrees including the Sc.D from the Massachusetts Institute of Technology in the department of Electrical Engineering and Computer Science. Her research group specializes in efficiency enhancement techniques and nonlinear circuit design for RF and microwave power amplifiers. Prof. Barton has received the AFSOR YIP and NSF CAREER awards and received the IEEE MTT-S Outstanding Young Engineer Award in 2023.

Yaqub Mahsud received the B.S degree in Engineering from Harvey Mudd College in 2021, and the M.S. degree in electrical engineering from the University of Colorado Boulder in 2024, where he is currently pursuing the Ph.D. degree in the RF Power and Analog Lab. His research interests include efficient, linear, and broadband power amplifier architectures.

W-5

11:15 – 12:00

Advancements and Challenges in Testing, Modeling, and Linearization of LSMA Transmitters for 5G/6G: From GHz to Sub-THz

Slim Boumaiza (University of Waterloo)

As 5G technology rapidly advances and 6G looms on the horizon, the need for innovation in the testing, modeling, and linearization of large-scale multiple antenna (LSMA) transmitters has never been greater. This talk will explore key challenges in predicting and addressing the nonlinear behavior of LSMA transmitters, emphasizing the role of co-simulation frameworks in advancing design and testing methodologies. We will explore critical questions, including: • Should LSMA transmitter demonstrators be developed for proof-of-concept validation at the component level, such as for power amplifiers? • Is over-the-air (OTA) testing in far-field or near-field environments essential, or can augmenting connectorized systems strike a balance between accuracy, cost, and time? • Are current linearization techniques sufficient to handle LSMA nonlinearity under varying conditions like precoding and dynamic resource block allocation? The talk will then provide a brief introduction to the state of testing, modeling, and linearization methods for sub-6 GHz (FR1) digital beamforming transmitters, before shifting focus to recent progress in millimeter-wave (mmWave) RF beamforming transmitters in FR2 bands. Finally, the talk will delve into the unique challenges facing the testing, modeling and linearization at the component and system levels at FR3 and sub-THz frequencies and will explore strategies to overcome them. By presenting the latest innovations and discussing future directions, attendees will gain valuable insights into optimizing LSMA transmitter technology for the 5G/6G communication systems.

Slim Boumaiza received his B.Eng. in electrical engineering from the École Nationale d'Ingénieurs de Tunis in 1997, and his M.S. and Ph.D. from École Polytechnique de Montréal in 1999 and 2004 respectively. He is a professor at the University of Waterloo, heading the Emerging Radio System Research Group in the Department of Electrical and Computer Engineering. He has extensive experience in developing high-performance and energy-efficient wireless transmitters for 3G/4G/5G and satellite communications. His expertise includes characterizing, modeling, and designing microwave and millimeter wave circuits, high-efficiency power amplifiers, linearization techniques, mixed RF/digital signal processing, and beamforming radio transceivers. He has received Early Researcher Award from Ontario Research Fund, NSERC Accelerator and Synergy awards and has published over 90 journal articles and 145 conference papers.

12:00

End of ARFTG Workshop